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ABSTRACT

The scope of this book covers metrication management. It was created to fill the middle management need for condensed, authoritative information about the metrication process and was conceived as a working tool and a prime reference source. Written from a management point of view, it touches on virtually all aspects of metrication and highlights the important factors. Emphasis is on the manufacturing business; however, information and ideas apply equally well to other organizations and businesses. Contents include chapters on planning, engineering, manufacturing, purchasing, marketing, computer systems, training, and cost. (MP)

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metrication for the manager

by john t. benedict

american national metric council

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**Metrication
for the
Manager**

By John T. Benedict

September, 1977

American National Metric Council
1625 Massachusetts Avenue N.W.
Washington, D.C. 20036

Foreword

In approaching metrication, the first step—and ultimately, the most important step—is the intellectual commitment. This entails a wholehearted, unreserved acceptance of the need to “get on with the task.” You drop that last “shred of doubt.” And you are free to move ahead; no longer unconsciously uncovering reasons to postpone metrication—but, instead, finding and recognizing the ways to do it.

The next step is to develop and fix firmly in your own mind an image of the kind of metrication manager you intend to become. Aim high. Should you settle for a lower level of competence in metric than you now possess in the U.S. Customary measurement system? Certainly not! . . . Surely, your own sense of the metric proficiency to be attained is not satisfied by assuming:

- There isn't much to it; I'll just pick it up.
- I didn't have much trouble when I was in Europe last month.

No. That would limit you to a level of metric proficiency equivalent to “street jargon” or pidgin English. When you think of it that way, the informal, unstructured, haphazard “just pick up what I need to know” attitude does not lead to a desirable goal.

Your aspiration is higher than that. You are an educated, literate person. You are adept in the U.S. Customary inch/pound measurement system. You use it easily, correctly, “fluently.” In time, you wish to become equally “fluent” in the SI metric measurement system. That is a proper, fitting goal: to function as well with metric units and terms as you presently do with the familiar inch/pound units. And, further, to become an able practitioner of the special body of knowledge and skills required for effective management of the metrication process.

SI, The International System of Units (the modernized metric system), is one “discipline” or body of knowledge. “Metrication Management” is another. They are not the same. They are, of course, inter-related.

By setting and attaining high standards in SI competence, you'll assure your own individual proficiency and productivity as you progress through the transition leading to gradually increasing metric orientation in your everyday tasks. In addition, as a manager, you'll be a positive influence on the people who work with you—and, in effect, serve as a model for correct usage of SI metric units and their application in your particular field.

The Scope of this book covers metrication management. It includes (p. 45) only the rudiments of the SI metric measurement system, as promulgated officially for application in the United States. In the Sources of Additional Information section (p. 47), you'll find listed a number of authoritative references for complete information on the new SI metric system.

This book was created to fill the middle management need for condensed, authoritative information about the metrication process. ANMC produced it expressly to assist you in the early stages of your thinking. It is meant to be a convenient “metrication planbook”—to help you identify and understand the main considerations that should be taken into account. Written from the management point-of-view, it touches on virtually all aspects of metrication and highlights the important factors.

Material in this book is based on information and experience developed from extensive study of metric transition management in the United States and other countries. It is intended to be useful to middle managers in large organizations—and should be particularly useful for small and medium size firms which may not have a full-time planning department. Emphasis is on the manufacturing business, because this type of firm will be affected to the largest degree. However, information and ideas apply equally well to other organizations and businesses.

In this state-of-the-art publication, you'll find material on key aspects of metrication—to help you determine priorities for metrication planning and management. A special feature is the “Voice of Experience” section, containing a distillation of experience and practical advice from people who have had an active part in the metric conversion process.

The ANMC conceived Metrication for the Manager as a working tool and a prime reference source. We hope it will contribute to your effective handling of your responsibilities.

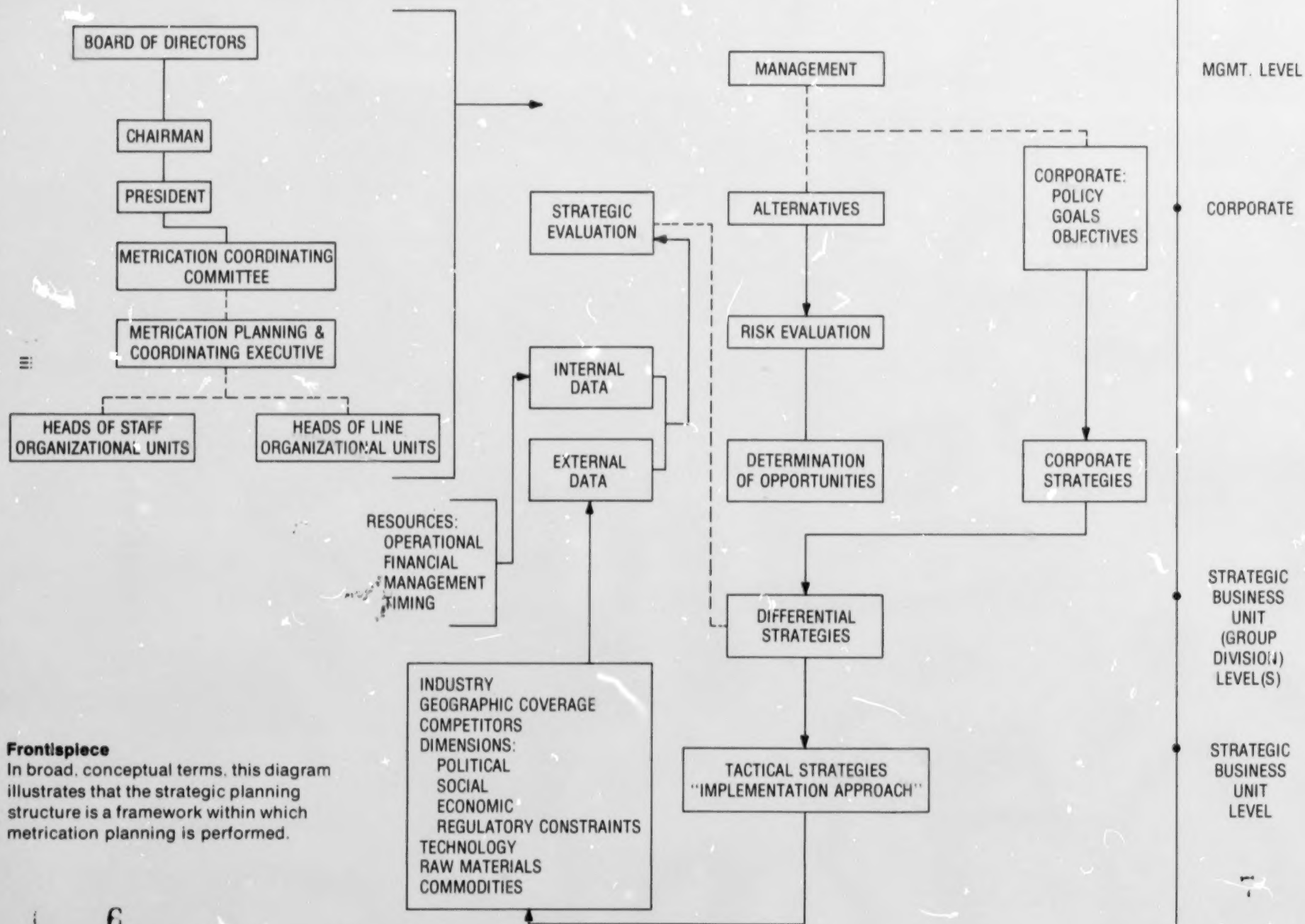
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About The Author

John T. Benedict, a recognized expert on metrication management, is manager of Technical Information in the Chrysler Corporation's Engineering Office. He was active in the founding of ANMC, served on its first board of directors, and is presently a member of ANMC's Highway Vehicle Sector Committee. Mr. Benedict has written numerous articles on metrication, and has spoken on the topic before the American National Standards Institute, the Society of Automotive Engineers, the Motor Vehicle Manufacturers' Association, the Standards Engineers Society, the American National Metric Council and other organizations.

Strategic Framework for Metrication Planning



Introduction

Technology does not stand still. Change is "the only constant." And the management of change calls for the highest order of skills possessed by today's managers.

In a large, highly industrialized nation such as the United States, a change in the system of measurement presents both challenges and opportunities to leaders in government, business, and industry. The challenge is to carry out the metric changeover with short-term minimum cost and disruption. The opportunity lies in the potential for achieving substantial long-term benefits.

Growth and progress of voluntary changeover to metric measurement was stimulated by passage of the Metric Conversion Act of 1975 (PL 94-168). By law, the Federal government thereby adopted an official policy "... to coordinate and plan the increasing use of the metric system in the United States, and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system..." Throughout the country, the metrication* trend has been accelerating noticeably. Further impetus will be supplied by actions arising from implementing various provisions of the Law.

The
climate for
metrication
programs is
improving

The climate for planning and implementing metrication programs is improving. Two indications of this come from the way most organizations are linked to the ongoing U.S. metrication trend. First, if your firm is a typical supplier—awaiting its own market-driven metrication to be triggered by metric orders from customers—there is increasing likelihood that such orders will be received. Secondly, if your firm is a typical manufacturer—visible progression of metric conversion in your industry will provide strong stimulus for launching your own product-driven metrication program. If you are a middle management person in government, you, no doubt, are aware of metrication planning activity in your particular agency or bureau.

This is not to suggest that metrication planning will be a simple task, nor that you'll find an unobstructed path for program implementation. It simply means that there is a more responsive atmosphere for some metrication ideas you may have been nurturing. It also means that your proposals for metrication action will meet with greater interest and receptivity... and, to your surprise, may even be welcomed!

By acquiring and applying expertise in metrication management, you can assist in developing an optimum cost-effective strategy that takes advantage of opportunities and benefits that attend a long-term program for transition to SI metric in your own organization.

As usual, a good way to begin is to define the problem. What must be done to transform your department or your organization into a metric operation? In which aspects of your functions or your business are you able to initiate metric changeover? In which areas are you in the role of responding to metric inputs from others? This involves investigation, and some study is required.

Metrication involves two general types of conversion that, conceptually, are independent—but which, in practice, are virtually inseparable. The first is limited to adoption of the SI metric measurement system—sometimes called soft conversion. The second is change from standards and design modules based upon the inch system to those based on the metric system—usually identified as hard conversion. Informed decisions, clear judgment, and managerial skill are required to plan and guide the long-term metric transition and determine the best mix of soft and hard conversion in each situation that arises.

Experience has shown that, by whatever combination of action or reaction an organization arrives at a metric commitment, a positive attitude should guide ensuing actions. An alert, aggressive spirit can identify and attain benefits that will elude those who use a passive approach. Whether one enters metrication by choice or by necessity, it should be recognized that "the inevitable" changeover to metric measurement has begun—and a positive acceptance can aid in getting best overall value and economic gain from the change.

*"Metrication:" a broad term that means "actions directed toward increasing the use of the metric measurement system."

Executive Summary

In broad overview terms, a company metrication effort progresses from investigation to planning and implementation. After adopting a metrication policy, most companies form a top-level Metric Steering Committee to develop a plan and oversee the implementation. Representation usually covers such areas as Engineering, Purchasing, Manufacturing, Sales, and Finance. Large companies establish interdivisional or "group" level working committees to administer the metric activities of areas whose functions are closely inter-related. At the plant level, operating units have part-time metric coordinators. They serve as a focus for the ongoing metric activity in each area, and also provide a liaison with the Corporate level group for problem-solving and dovetailing inter-dependent metrication programs. Task forces are created as needed to work on specific subjects.

A typical company policy calls for gradual increase in use of SI metric units until they replace inch units as the predominant system. Responsibility for taking the lead usually is assigned to Engineering, although it sometimes is given to Manufacturing or Product Planning. To foster a common understanding and a uniform approach to metrication, the policy is augmented by a set of guidelines and a program definition that includes the metric product plan. Typical guidelines are:

- Metrication to be accomplished within existing organizational structure.
- Initial policy commits to soft conversion (adopt equivalent metric measurement units) plus advanced state-of-the-art use of metric standards (hard conversion).
- Use SI metric units in new designs.
- Carryover inch-based designs as is.
- Provide interface as required between new metric elements and carryover inch design elements.
- Phase-out existing components in normal obsolescence cycle.
- Service parts to phase-out inch designs on normal cycle and become metric with new designs.
- During transition period, instruments and capital equipment with dual measuring capability will be required, on a selective basis.
- In its initial stages, the metrication program is applied to product-oriented items.
- During the gradual changeover to metric measurement, supplier coordination will be provided, as required to accommodate existing metric capabilities at any given time.
- Develop metrication timetable keyed to normal cycles of change in products, equipment and facilities.
- Metrication costs usually are treated as part of the regular program costs; no separate metrication budget is to be created.
- In developing metric capability, keep pace with ongoing trend in your industry and the rate of metrication in government regulations that affect your products or your business.
- Accommodate actions that ensue from U.S. Metric Conversion Act of 1975.

From a management point of view, metric conversion is viewed as a major, long-term project that will, to some degree, affect every department in the company. In view of metrication's scope and long duration, careful planning and effective management are essential.

The most valuable aid to smooth, orderly metric transition is the willingness of people, at all levels, to make the change. Clear evidence of top-management commitment and interest is a key factor. A positive, reasonable attitude can engender good response and call forth the resourcefulness that is vital to an economic, well-paced program.

Follow-through is important: Watch out for the pitfall of "tokenism"—where top-management has set policy and put in motion the things to be done . . . then, seemingly, relegated metrication to a "back burner" status of non-priority.

Top-
management
commitment
is a key
factor

Metrication will be a part of every manager's responsibility. It will be regarded as a regular part of his job, it is to be accomplished as an added function, performed within the existing organizational structure—and budget, and through normal channels and working relationships.

The concept presently favored calls for various functions and areas of responsibility to prepare their own metrication plans and conduct their own metrication programs, based on: Corporate policy . . . a metric product plan (including schedule) . . . and a set of guidelines. The general approach provides minimum central administering and coordinating for the overall program; plus a Corporate metrication "nerve center" or information clearinghouse function. The intent is to begin with a product-oriented changeover to metric measurement and assimilate the change gradually, over a suitable time period, in a manner that would be least costly and disruptive.

Management has been called the "motor" or driving force for metrication. The metric changeover will be least-costly and disruptive if properly managed. Management activities are illustrated schematically by the diagram shown in Figure 1.

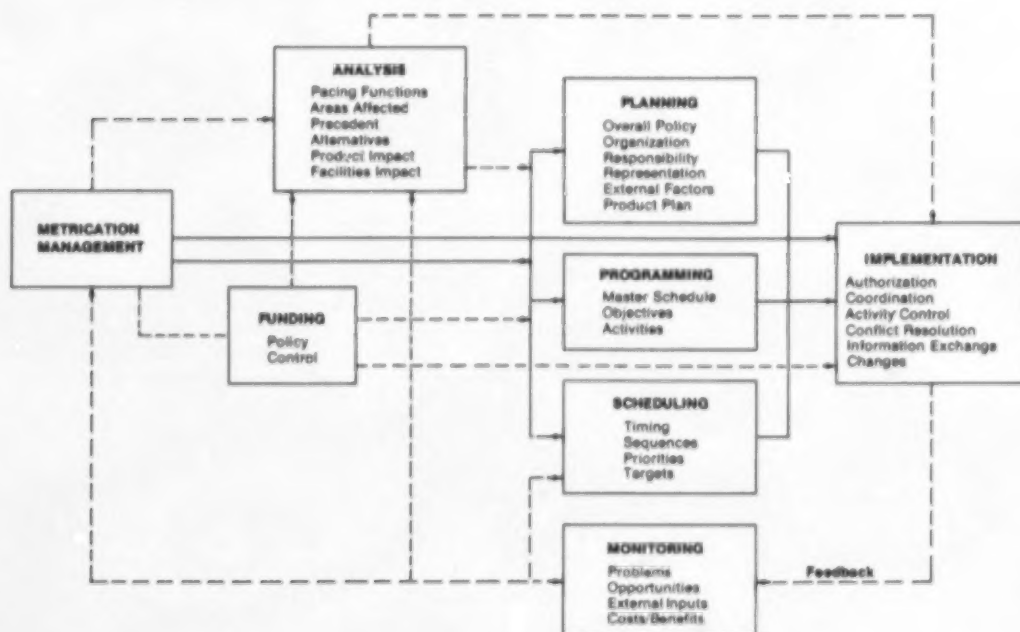


FIG. 1 Metrication Management Activities

An aspect of metrication management that requires careful attention is the need for a balanced, well-modulated approach that administers the ongoing activity so that the many diverse areas move in concert. This requires, on the one hand, constraint against haphazard, premature or precipitous action . . . and, on the other hand, the need to delegate responsibility and foster initiative.

In sum: plan, but don't over-plan; manage, but don't over-manage. Flexibility is vitally important in achieving an effective metric transition.

Metriation Policy

Once the decision to go metric has been reached, one of the first requirements is formulation of an appropriate policy. The main purpose is to document the metriation commitment and point out the general direction to be taken. Internal communication of the policy indicates that top management has come to a firm decision and that cooperation in implementation is expected.

Common
element
is. . .
intent to
adopt
SI

Specific content of the policy statement and the amount of detail it contains vary widely from one company to another. However, the key common element among such policies is, of course, a statement of the intent to adopt the SI metric measurement system. The International System of Units. For example, the SAE Metric Policy States: "The Society of Automotive Engineers recognizes the rapid growth of metric usage, particularly in the industries it serves. It is the policy of SAE to change to the modern metric system (SI) in a manner and on a schedule that is in harmony with the provisions of the U.S. Metric Conversion Act of 1975, and that best serves the interests of SAE members and the public at large . . ."

Shown here are examples of policy statements used to establish internal direction and as a basis for external announcement of plans to enter into a metric transition program.

COMPANY ABCD

GENERAL APPROACH AND PHILOSOPHY OF CONVERSION (TO SI METRIC)

Metric Policy

- As of 9-27-73, there is an established Corporate policy to support a planned program for an orderly substitution of SI metric units of measurement for the customary units now in use to the extent that SI becomes the predominant (but not necessarily exclusive) system of measurement for company operations.
- This policy applies to all Offices, Operations, Groups, Plants, Facilities, and Subsidiaries. The specific Metriation schedules and plans will be formulated by each Division on the basis of their cost effectiveness for the concerned organization. Such factors as anticipated markets, customer requirements, cost of conversion and supplier and subcontractor relations will be considered.
- Groups, Plants, Facilities, and Subsidiaries are encouraged to use SI units in all technical reports unless otherwise constrained by customer requirements.

Metriation Officer

- The office of the Vice-President--Research and Engineering (Corporate) has been assigned the responsibility for the overall coordination and review of efforts leading to the adoption of SI measurement within the Corporation. The Vice-President--Research and Engineering has been assigned the overall responsibility for supervision of implementation and compliance with the Policy and for the issuance of supplemental procedures as required.

Metriation Steering Committee

- In late 1972 the Corporation established a "Metriation Steering Committee" including a representative from each of the Groups within the Corporation. Corporate P.R., Operations, Material, and Personnel representatives are also provided for.

November 13, 1973

A LARGE MANUFACTURING COMPANY

Corporate Policy: Metrication

Units of measure employed by the Corporation have been determined by historical practice. Impending changes in industry practice and in government legislation require a Corporate Policy to guide management.

It is a Policy of the Corporation:

1. To take selective action as required to convert the Corporation's units of measure eventually to the SI metric system consistent with domestic industry practices and on a timing and cost basis serving the overall interest of the Corporation.
2. To support selectively and participate in metrication studies and related planning performed by technical societies, trade associations, and other standards making groups.

Delegation of responsibilities

Product Planning Office

- Establish metrication planning assumptions and provide planning assistance for the utilization of metric units.
- Recommend the use of metric units in corporate products.

Engineering Office

- Coordinate the activities of all offices and staffs concerned with the implementation of metric usage. Publish corporate standards and product development technical instructions prescribing authorized metric units of measure and conversion conventions. Provide guidance to other activities in the development of instructions in their areas.

All Offices And Staffs

- Provide information and data as required and actively participate in the development of plans and programs for metric usage.
- Review the requirements for and advise the Engineering Office of programs proposed to accomplish metrication.

Scope: This Policy applies to all components of the Corporation.

SPONSORED BY:

APPROVED BY:

June, 1974

XYZ METAL CORPORATION

Metrication Policy

It is the policy of XYZ Metal Corporation to proceed with metrication as required to most effectively meet the needs of our customers. Implementation of this policy will concur in every practicable way with such policies as are established by the Federal Government, the American Iron and Steel Institute, and the industries served.

Metric-dimensioned products will be supplied whenever possible, within the limits of practical economics for both XYZ and our customers. By mid-1975 it is the intention to accept orders for designated products in either customary or metric units. Metric-dimensioned orders for such products will be produced in equivalent customary units, but invoices and shipping papers will be provided in either sets of units, as requested by the customer. Production of all other mill and fabricated products in metric standard sizes will be considered whenever orders for specific products and sizes are large enough to enable the cost of necessary rolls, tools, and dies to be amortized adequately.

August 3, 1976

FEDERAL COMMUNICATIONS COMMISSION (FCC 76-7371)

International System Of Units (SI) ... Program Adoption

On July 28, 1976, the Commission adopted a program for converting to the use of metric units. This program will facilitate development and use of a single system of units in the FCC rules. The program will be in accord with the objectives of both the House of Representatives Bill (H. R. 254), and the Senate Bill (S. 100).

Metric units will be used in all new and amended rules. Metric units will also be used on all license, equipment authorization, and construction permit applications, after complete conversion to metric units in the rules is accomplished. In the interim, the measurement system that is used in the relevant rules when filing an application should be used.

The program involves a gradual two stage conversion to metric unit usage. Metric units will appear with the U.S. equivalent stated in parenthesis Example: 2 meters (6:56 feet). This program will allow for a smooth transition into metric unit usage.

Action by the Commission July 28, 1976. Commissioners Wiley (Chairman), Lee, Hooks, Quello, Washburn, and Robinson.

FEDERAL COMMUNICATIONS COMMISSION

Vincent J. Mullins, Secretary

Federal Register, Vol. 41, No. 154--August 9, 1976

Metrication Committee

Many organizations have found it desirable to appoint a top-level metric coordinator and establish a metrication committee to assist in planning, coordinating, and implementing the metric program. Authority for development and implementation of a metrication plan lies within the corporate policy and practices established in conjunction with the plan, and as authorized by top management of the company.

When the decision to go metric has been reached, one of two broad approaches will be applied, depending upon the company's size and managerial style. In an informal or quasi-official manner, corporate technical staff or the engineering department will begin to plan and carry-out the early movement into a metric product . . . or, more formally, a metric task force may be appointed to begin the planning. However, regardless of which method is used, it is vitaly important that the planning body adopt an overall approach to metrication . . . one that takes into account all functions and areas within the company.

Management
support
should be
visible

The decision to convert must have the full support of management. And that support should be visible. In addition, top executives in each area should take the necessary steps to inform all personnel of metric planning. But the announcement and ensuing communication should be low-keyed, to avoid over-reaction. At first, many people will know little about the SI metric system, and they'll certainly lack the know-how required for effective management of a metric transition. Hence it is important that the announcement does not create anxiety or make people fearful of the change.

Metric Coordinator

Management should designate an executive head for metrication planning and coordination. This function is sometimes called "metric coordinator"—and the assignment often is given to the chief engineer or director of standards, as an extension of his normal responsibilities. Usually, this same person serves as chairman of the Corporate Metrication Coordinating Committee, to administer and oversee execution of the metric policy.

The metric coordinator should be an able, broad-gage individual with a strong technical background, plus extensive knowledge of the company's various functions and products. In brief, he should be well-versed in the workings of the firm, and knowledgeable about the products marketed. Whether by job rank, or by personal qualities, he should be a person of stature—well accepted throughout the organization. He should have the respect of managers who will be involved in the conversion program, and should be able to maintain a working relationship between top-management and the metric committee. In some instances, the job of coordinating and directing the total metrication effort is full-time, but in most firms, it is part-time—a new responsibility that is viewed as a logical addition to some regular function.

Regardless of company size, every metric committee has many general responsibilities. However, the large decentralized firm requires a relatively extensive metric organization, including a corporate metric coordinator. This official is responsible for coordinating the metrication effort. He also serves as liaison between top-management and the divisional metric coordinators. Along with other managers from corporate headquarters and operating divisions, the corporate metric coordinator forms a steering committee or metrication coordinating committee, as it often is called. This committee's task, typically is to:

1. Develop a working knowledge of metrication in all areas of company operations.
2. Establish criteria or guidelines for conversion in each division.
3. Develop a metric transition plan for corporate headquarters.
4. Combine plans of corporate staff and operating divisions into an overall "master plan" for corporate metric conversion.
5. Coordinate and oversee implementation of the metrication plan.

At the group or division level, when the time is right to proceed into metrification, actions are guided by the overall plan. Local priorities are set for the various operating parts of the division. These are, for example: engineering, manufacturing, marketing, purchasing, systems & operations, finance, legal, product planning, service, and personnel.

Usually, a "metric focal point" or metric coordinator is needed in each division and functional area, to formulate specific guidelines and plans. Coordination with the corporate plan via the corporate committee and the "metrification nerve center" is pursued at the discretion of the divisional management and metrification team. Responsibility for metric implementation, communication, and coordination with other units of the company lies with the division or groups concerned. Refined division or group planning is anticipated as necessary, and will be based upon each unit's circumstances, including economic feasibility and guidelines.

Organization

Corporations and government agencies have a myriad of sizes and shapes. Each has its own structure and personality. A large decentralized corporation may have several steering committees at various locations and levels. A smaller, more centralized firm may have only one. And many small firms may not need a formally constituted steering committee at all . . . the metric coordinator (who may be the chief engineer) takes the lead role and assumes total responsibility.

In a corporation of several divisions, the metrification organization structure may be as shown in Figure 2. For purposes of organizational planning, the important point to note is that the new metrification function is "grafted" into the existing structure and functional distribution; it is neither necessary nor desirable to create a "separate apparatus" for metrification.

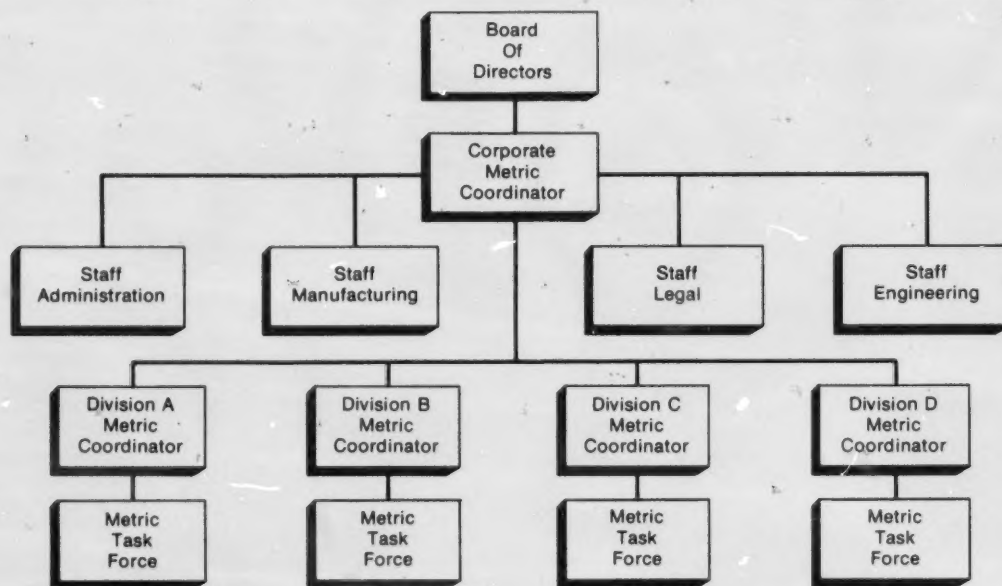


FIG. 2 Corporate Metric Organization Chart.

In large corporations with several divisions, a decision must be made whether or not each division can convert to the metric system on its own plan and establish its own timetable. In particular, if overseas divisions are involved, metric may already be the predominant system of measurement—but they may be in transition to SI, from variations of former metric systems—and careful attention to detail is critical in international joint planning for metrification.

Committee responsibilities in a centralized corporation parallel those of the division-level committee in a multinational, decentralized corporation. In some instances, top-management appoints a metric task force to investigate metrication and make recommendations. If the firm's products and operations are found "sensitive" to metrication, the same committee or ad hoc task group would develop and implement a conversion plan.

Metric Coordinator at the Operating Division

Divisional metric coordinators should be responsible for planning and implementing metrication at the division level. They should be chosen by division management—and, like their counterpart at the corporate level, should be at middle management level in the company organization and have the respect and cooperation of their associates. One method often used to assure proper "standing" and encourage cooperation is to define the metric coordinator as having a special assignment and arrange that, for purposes of performing this function, he crosses organization lines and reports directly to the top-executive in his division or area. A division metric task force, comprised of the division coordinator and department heads involved in the conversion, should also be formed. The coordinator's duties include:

- Setting up committee meetings
- Initiating the division metric library
- Establishing departmental coordination
- Liaison between division and corp. office

One large manufacturing company describes its organizational alignment this way: A system of metric coordinators has been created at all levels of the corporation. These are part-time assignments given to people in responsible positions. Each division and staff has assigned a part-time person to head up their conversion activity. He reports directly to the general manager or staff head in matters of metric concern. There are several dozen coordinators, having regular jobs covering a broad range. The divisional coordinators, in turn, have as many departmental or plant sub-coordinators as required by their local situations.

Metric Awareness

Changing to a new system of weights and measures causes psychological problems which must be overcome if metrication is to be successful.

Initially, the metric committee must be convinced that metrication is necessary. They also should be well informed on current metric developments in their field, and in the country as a whole. Once the committee is knowledgeable, key people should be brought into the planning. A good method to do this is to prepare a schedule requesting various department heads or representatives to join the committee meetings, to discuss metric impact in their respective areas. A metric educational briefing could be included, to calm any transition fears. It is important that employees know why you are converting, as well as how to apply the metric system on their jobs. Out of this will come a better understanding of metric by more people, and a feeling of participation in the transition process.

After involvement has begun, department heads should have metrication brought to their attention on a continuing basis. This can be done in various ways, such as:

- Join the American National Metric Council; circulate ANMC publications; take part in sector committee activity; and attend selected seminars.
- Subscribe to metric periodicals and circulate them.
- Selectively distribute metric articles from newspapers and magazines.
- Contact trade organizations and technical societies; obtain material on metrication.

There is an ever-increasing amount of metric information available from metric groups, technical societies, trade associations, the general press, and the Federal government. A company metric library or information center can help to organize these materials so they can be put to the best use. However, you should make sure that all materials obtained are accurate and conform to accepted metric practice.

Planning

A plan is needed to guide metrication policy implementation. Typically, it covers a 10-year period. The main purpose of the plan is to provide a coordinated, company-wide program for orderly changeover to the metric system. A planned program can minimize cost and confusion, and maximize efficient management during the transition period. The metrication plan directs actions following the "rule of reason." It can help avoid precipitous actions and unsound, over-zealous metrication decisions ("metrication for metrication's sake").

The metrication plan is based upon a set of broad "assumptions", with well defined dimensions and scope, covering key internal and external factors, such as:

- The Product Plan, Work Plan, Capital Plan, Business Plan, and International Operations of a particular organization.
- Industry metrication trend.
- U.S. national metrication trend.
- Metrication in Federal gov. agencies.
- Metrication of regulations affecting products and business.

Adoption
of a
rigid plan
would be
unrealistic

Considering the many variables involved, as well as the complexity and "dynamics" of metrication, adoption of a rigid plan would be unrealistic. Instead, it should be recognized that the plan must be flexible. Often, the schedule is not detailed, and provides only a general timing framework; sometimes there is no formalized schedule prepared at the beginning of metric transition. This permits the necessary adjustments to be made as events unfold. Thus, the plan provides a beginning, a point of departure, from which the present can be guided and the future can be visualized.

Potentially, metrication offers significant long-term benefits, but they can be attained only by thorough investigation, careful planning, and effective management. At the outset, one should realize that metrication isn't "something we've done before"; it isn't even like anything we've previously done. Changing measurement systems will be a completely new experience.

Early in the pre-planning stage, a crucial judgment is needed to "position" your organization with regard to leadership or "followership." In essence, this involves top-level direction to assume a role of forcing the trend, setting the pace, or following the trend. It is apparent that these are merely broad, descriptive terms, and that the interdependence and interaction among organizations means that such distinctions cannot be clear-cut. However, a well-directed, judiciously timed metrication program can set the right course for a particular organization and make it a dynamic participant in the wave of metric progress. To wait too long may cause a serious jolt—when it is discovered that metric progress must be home-grown . . . it cannot be bought or transplanted!

The decision to launch a metrication-planning effort, then, can evolve naturally, from a background of perception that "some sort of a plan" is needed to guide the metric conversion program. Or, recognition of the need for a plan may "dawn" abruptly—with receipt of "that first metric product order" by a firm that is unprepared. It is obvious that each company will require some uniqueness to its planning, even though there also is some area of similarity from company-to-company.

Developing a Plan

The key thing to remember when developing a metric plan is that your company should attempt to follow its own optimum path, while "moving with the metric tide" in the United States. Metrication should take place in a way that is practical, economically feasible, and in tune with the marketplace. It is especially important to devise a metric implementation plan based upon the specific resources and individual characteristics of your own organization . . . taking account of metric planning's strategic aspects, and operating within the normal planning structure in your company.

Metrication usually passes through three phases (Figure 3): (1) an investigation phase, where data are assembled and involved people begin their metric self-education; (2) a planning phase, where the data are shifted and correlated, and projections are made for implementation; and (3) an implementation phase.

In practice, of course, the three phases often overlap . . . and it frequently is necessary to "go two directions at once"—in the sense of having actual experience with the first metric product at the same time guidelines and plans are being formulated.

Once management has decided to go metric, a decision must be made on the type of conversion: soft or hard. Soft conversion refers to measurement units—and means changing numbers from the customary U.S. inch/pound system to SI metric. There is no physical change in the object itself. Hard conversion, on the other hand, refers to standards—and usually entails a change in the product. To decide: consider availability of metric standards and impact on suppliers and customers in this country and overseas. Consider impact on competition; would you gain a marketing advantage? How would tooling and machinery be affected if you undertook hard conversion? The life cycle of your product and inventory on hand, may affect your decision. Gather all the data before making a decision.

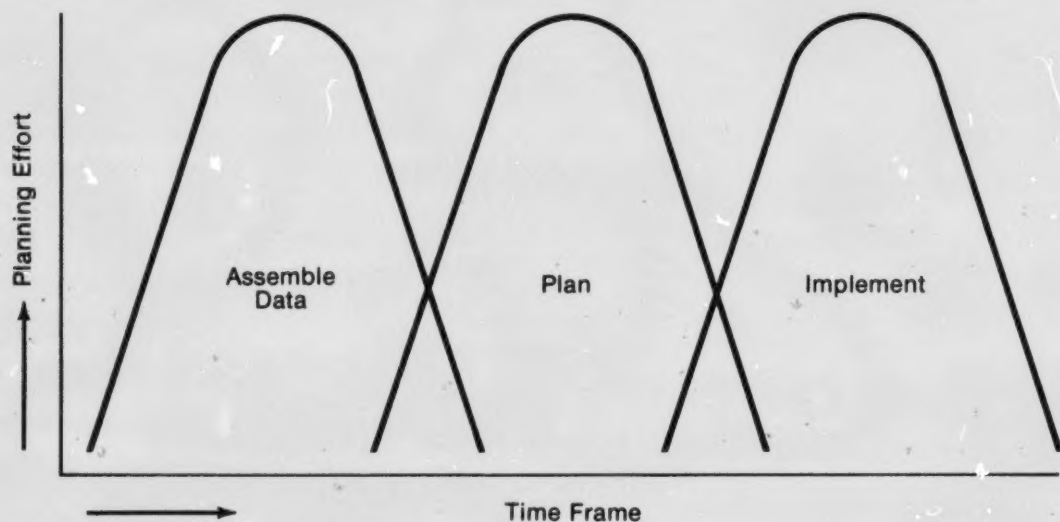


FIG. 3 The Three Phases of Metrication.

Metrication Timing

Many elements affect the timing of metrication. For example, a large, multinational firm may be able to act as a leader in conversion. Suppliers and customers will follow its direction. However, timing should be such that suppliers can adapt and make the necessary changes; the customer should not "out-pace" the vendor's metric capability.

Usually the best time to implement metric conversion is when there is a major design change or when a new product is to be introduced. The initiative for startup and timing of your whole plan may rest with your customers. If your firm does not produce an end product, or if the product becomes a component of a larger machine, you should contact customers, to establish guidelines that will coordinate and dovetail the interdependent plans of the buyer and the seller. Questions of competitor and market reaction will influence your plans. Could customers accept metric products now, if they were available: The purchasing department must contact your suppliers, to determine availability of metric components and parts.

To use an aerospace expression: each company should determine its own individual "metrication launch window"—the time when major factors combine in establishing the most propitious time for cost-effective start-up and follow-through on metrication. At the strategic planning level (see Frontispiece, p. iii), the main inputs for determining your particular "window" are:

- The U.S. national metric trend
- Your own industry trend
- Your product plan
- New product schedule and life cycle
- International product programs
- Strategic planning assessment

From consideration of these factors can come perception of your window for metrication launch, a judgment of when to give the "go" signal for implementation, and a basic understanding of the best pace and duration of your metrication program. These are critical factors, because launch timing, program pace, and duration have a crucial effect on cost.

Once timing is determined, an overall conversion schedule can be prepared. Check points should be added to the schedule to monitor metric progress.

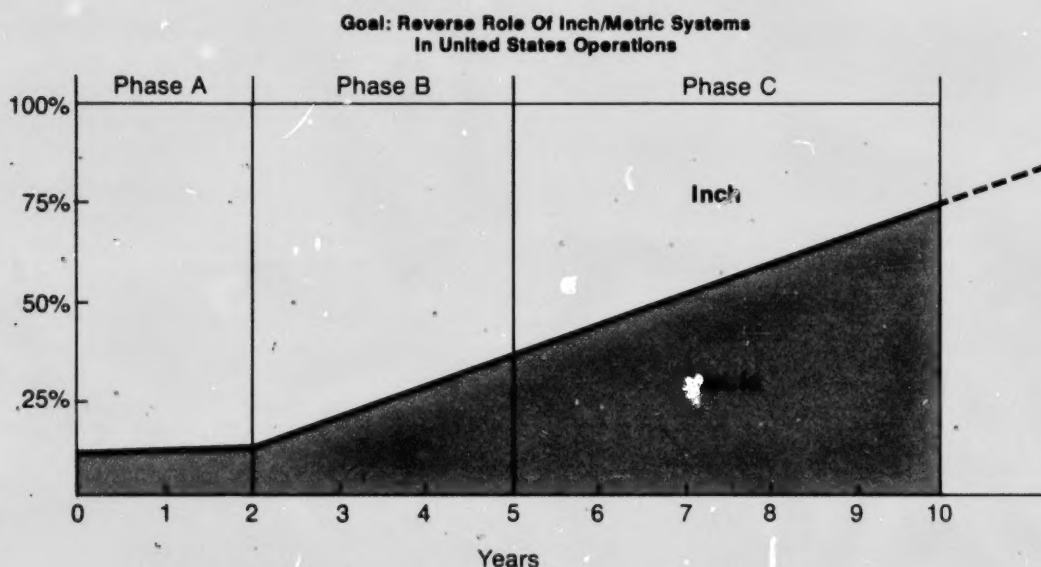


FIG. 4 Corporate Metrication Plan.

Figure 4 illustrates a composite corporate plan. The goal is summarized as "Reverse Role of Inch/Metric Systems in U.S. Operations." Beginning with nominal level of metric usage, the plan progresses over a 10-year period toward predominantly metric application in design and production.

Phase A—Groundwork—A period in which various studies and actions in design, production, purchasing, operations, and marketing are taken to build a state of preparedness.

Phase B—Adaptation—A period in which the first metric program is begun, and specific adaptations are made for accomplishing it in what still is, essentially, an inch-oriented organization.

Phase C—Applicability—A period in which metrication is implemented vigorously, to develop a full metric capability.

Figure 5 illustrates how a division or unit of a company might set its own planning within the corporate plan, and progress through Phases A, B, and C. The light grey area on the bars represents "begin metric transition toward 50% metric capability." The medium gray area is the period "extending over 50% metric capability." And the darkest bar is the time for "approaching full metric capability."

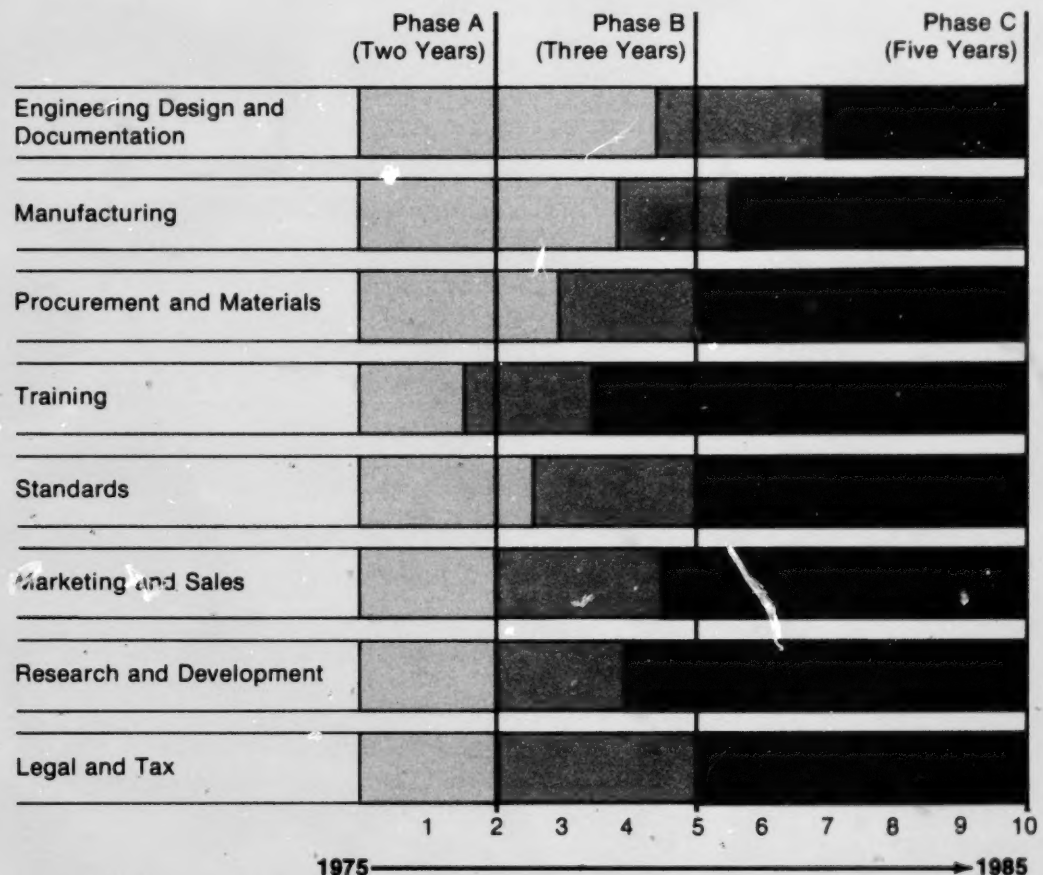


FIG. 5 Metrication Plan Chart.

Study and analysis are useful in the early stages of metric planning. Throughout the company, each organizational unit and department should begin developing a checklist outlining what must be done. Figure 6 shows an example of an internal memo that one firm used as part of its study . . . and a comprehensive checklist begins on page 38.

A pilot program may be conducted early in the planning effort. Use of this approach depends on the corporate structure—but a pilot program can be valuable in determining conversion problem areas. The program could be set up as follows: (1) isolate a particular new product

You are requested to conduct an investigation to determine the potential impact of a complete change-over to the SI metric measurement system.

By direction of Mr. _____, this preliminary Study is undertaken as a step toward planning and preparing for metrication action program. That program will provide for an organized approach to a gradual transition aimed at making SI metric the predominant system of measurement within the Corporation.

In this Study, you should identify what will be affected by eventual adoption of the SI metric system. Additionally, for a substantial sampling of the items affected, you should make a preliminary determination of the various optional means for accommodating the changeover to metric. At this point, you are not concerned with when and how the transition will occur.

To perform the Study, you should canvass your entire area and identify everything that is "measurement-sensitive." Examine all aspects of functions and resources ... and list those things that will be different when using metric measurements.

That is the primary task. However, as the Study proceeds, you also should identify some examples of "standards-sensitive" aspects of your department's output or end-product and the equipment you use. Thus, you will get some preliminary information on items whose size, shape, or general specifications are controlled by external standards ... and which, over a long time-period (and to an as yet unknown extent) will change as metric standards come into use in the United States.

Mr. _____ will coordinate the overall Metrication Study and work closely with you.

A Pilot Study is to be done first—using at least one department in each area, to gain some experience before launching the complete Study.

In regard to timing: the pilot results should be finished and assessed by _____, and a report on the full Study of this area is to be completed by _____.

FIG. 6 Metric Impact Study at Department Level.

program; (2) train engineers, staff, manufacturing personnel, and others; (3) prepare engineering drawings with metric dimensions and follow-through in purchasing, tooling, production, service, etc.; (4) run the program for a specified period of time; (5) evaluate the "learning experience."

The pilot program can be useful as a focus for investigating legal aspects of metrication. In many instances, close three-way cooperation must be maintained between the corporation

and its vendors and its customers. Meetings must be thoughtfully handled, with legal counsel as necessary, to avoid seeming violation of antitrust laws. Should communication and cooperation be required between competitors, some organizations may bring a charge of product allocation, price-fixing, restraint of trade, etc. Contracts should be examined, to determine implications and possible effects of metrication. Vendor agreements may have to be updated, distributor and sales contracts may have to be modified, and some aspects of labor agreements may need to be reviewed. Legal aspects need not be viewed as impediments or serious barriers to metrication . . . the caution simply is that they must be considered carefully—and handled competently, in consultation with expert legal advice when necessary.

Implementing the Plan

At this stage of preparation and progress into metrication throughout the United States, it is evident that in the real-world environment, many firms already are engaged in both "doing" and planning the metric changeover. When the plan is completed, it often is obvious that additional metric transition activity can get underway without any great expenditure.

Before rumors spread too much mis-information into your plant, consider issuing a brief notice, to inform employees and keep them from becoming overly concerned. There are advantages and disadvantages in doing this; but, if this approach is adopted, the following method may be applied:

1. Meet with department heads to explain the objective and the plan in depth. Outline departmental responsibilities. Present "the case for going metric" and ask their cooperation.
2. Meet with labor union representatives. Brief them, so they can answer questions brought to them by other workers. Be sure to point out that the changeover will be gradual, and discuss the length of transition. If a pilot program is planned, it should be discussed in detail.
3. Use various communication methods to reach employees. This may be done through a newsletter or meetings, etc.

Now begin setting up the transition. There is much that can be done without expending a great amount of funds. Obtain the necessary materials and organize a training program. Develop your metric drafting standards and begin metrication of your engineering standards. Continue to monitor metric activity among your customers and vendors, and meet regularly to review your plans. Continue to evaluate your firm's position in the marketplace.

A point may be reached where a "proceed or hold" decision should be made. If your firm is multinational and decentralized, the advantages of conversion may far outweigh any disadvantages. The decision may have been made before planning was undertaken: proceed with no "holds." For some smaller companies, however, implementation can proceed toward developing a dual inch/metric capability . . . to a point of committing to metric drawings, metric packaging, and metric tooling and gages. Some firms may adopt a wait-and-see attitude, until it is feasible to continue with metrication.

For manufacturing companies, implementation begins with Engineering. New product drawings are the best place to start. As the drawings proceed through the company, metric awareness and involvement are triggered. As the program progresses, the activities of all departments should be coordinated to ensure that:

- Computer programs are modified as necessary
- Gages are available when needed
- ~~Test~~ packaging is ready
- ~~Revision~~ is made for metric inventory
- ~~3~~ is literature is prepared for distribution
- Other actions are taken as necessary.

Engineering

Assess impact on existing designs and new designs

When analyzing and preparing for the impact of corporate metrication policy in an engineering department, the first step is to determine which products, if any, are to be converted to the metric system, and when new products will be designed in SI metric units. The product metrication assessment (or "metric product plan") leads naturally to the broader task: identifying and quantifying specific areas of metric impact. Equally important is determining what other changes should be made concurrently with metrication, for maximum benefit and minimum cost. Questions to be considered are:

- What will be the impact on existing designs and new designs?
- How will product life cycle affect metrication plan and schedule?
- Should new standards be developed for:
 - design graphics
 - engineering specifications
 - engineering tables and data sheets
 - quality assurance specifications
 - calculation procedures (computer based and others)
- Should metric product design be:
 - pure SI
 - hybrid, metric/inch
 - inch module, soft converted
- What about provisions for:
 - rounding
 - dual dimensioning
 - codes and standards from outside sources
 - training

PLANNED PROGRESSION INTO METRIC ENGINEERING

One approach to answering the foregoing questions and undertaking a planned progression into metric engineering operations follows:

A generalized corporate metric organization is shown in Figure 7. The Engineering organization is linked to the corporate activity, each major segment having a task force in which the disciplines to be addressed are represented (i.e., heat and work transfer, mechanical, electronic, chemical, etc.) Thus, means for finding the metric impact on all levels of engineering are provided. Task assignments are devised to generate reports stating what is needed to carry out a metric transition and, ultimately, operate in the SI metric system. If desired, these reports can include at least rough estimates of man-hours required.

For purposes of identifying and organizing engineering metrication functions, they can be grouped into three levels of activity:

1. A common level
2. An ongoing level
3. A final implementation level

Common Level of Activity

To establish a uniform company-wide approach in selecting and applying SI units, an authoritative U.S. national standard document should be adopted for company internal use. The primary United States standard is American National Standard Metric Practice Z 210.1-1976, available from American National Standards Institute (ANSI), ANSI Z 210.1-1976 also is available from the two engineering societies that jointly prepared it: American Society for Testing and Materials and Institute of Electrical and Electronics Engineers. The two versions are identical, except that ASTM uses spellings "metre" and "litre;" and the IEEE uses "meter" and "liter." (For addresses, see Sources of Additional Information, pages 47-48).

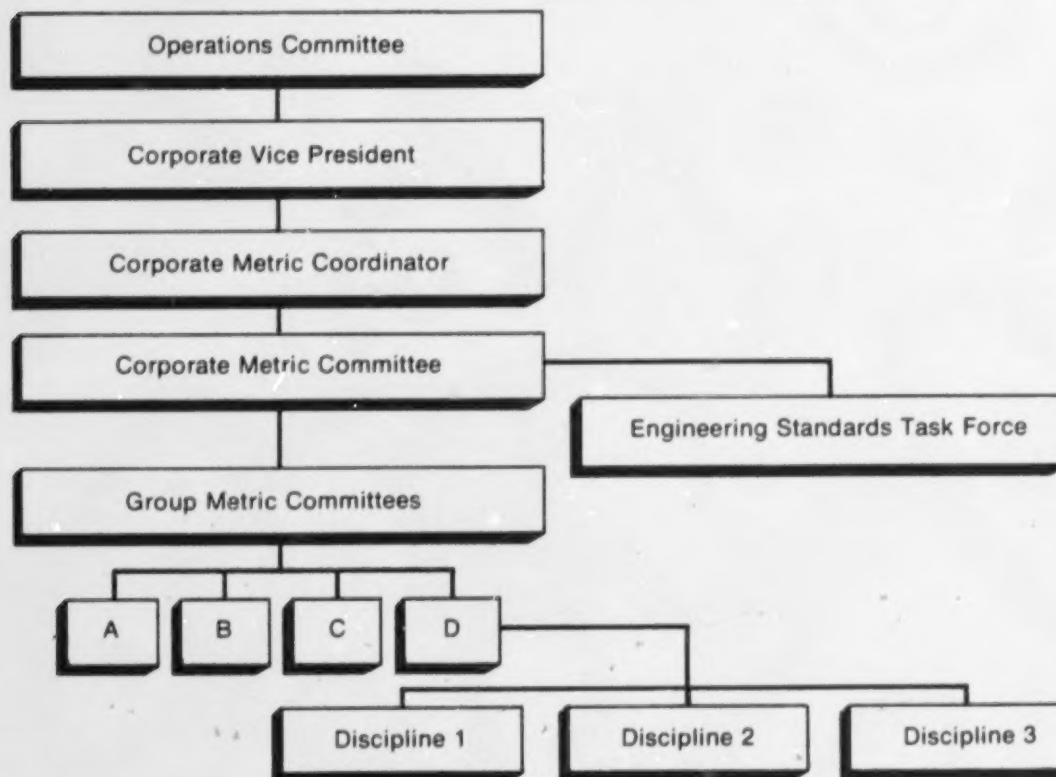


FIG. 7 Corporate Metrication Organization Chart.

Supplementary reference documents may include the ANMC Metric Editorial Guide, and the appropriate technical society or trade association publication.

Ongoing Activity

Ongoing activity includes addressing questions that have been stated previously. Answers reflect overall corporate policy and strategy, and become guidelines for Engineering metrication.

Dual Dimensioning: Emphasis should be placed on selecting a drawing method that will encourage and expedite the adoption of SI units, while allowing for a smooth and economical changeover. Obviously, a metric dimensioned—not dual dimensioned—drawing should be the goal. During the period of changeover, some form of dual dimensioning may be used. There are arguments both for and against the practice of dual dimensioning.

Proponents say that, in order to successfully move metric designs into an essentially inch-oriented manufacturing and supply system and achieve timely, quality production on an economic basis, inch equivalents of dimensions must be available for reference as needed . . . and that, whether done by complete dual dimensioning or by application of a computer-generated chart, the conversions should be dropped, selectively, when no longer needed by those who use the drawings.

Opponents argue that—when metric transition is the object—dual dimensioning (whether in chart form or otherwise) is an "expensive exercise in futility" . . . they say U.S. industry metric working capability already is widespread and is growing rapidly—and that a company's production plant or a parts supplier will quickly learn to use a "metric only" engineering drawing if that is all they are given. In essence, the contention is that conversion charts are not necessary—and, if provided, will prolong the changeover period.

A metric dimensioned drawing without any conversion is the eventual goal, but sometimes is difficult to implement initially. Conversions of SI units will be required during the transition period to eliminate repetitive conversions of the drawing data by the many users. Listed below are a number of reasons that justify the need for conversion data on a drawing:

- Engineers will require conversions to quickly check out interface dimensions of parts dimensioned in both SI and customary units.
- Many existing data processing programs will not handle both measurement systems.
- Suppliers of purchased finished parts or rough stock may not have made a decision to convert and may supply in customary units only.
- Numerically controlled machine tools and other equipment such as jig borers, that are calibrated in inches will require conversion data until the machine is converted or replaced.
- Gages and tooling identification in either system of measure are easily recognized.
- Conversion, made only once by people familiar with the precision intent on the drawing, will reduce the possibility of error.

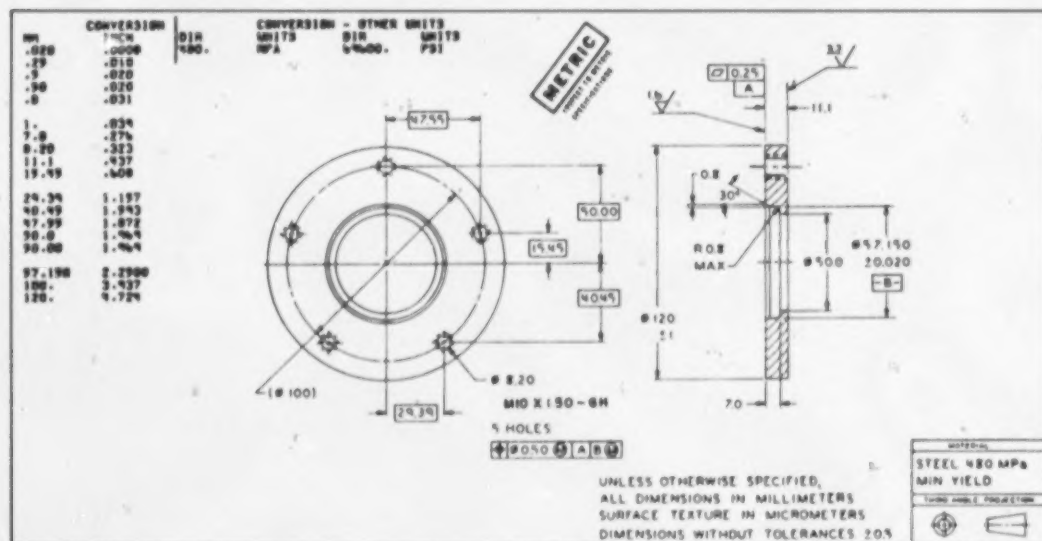


FIG. 8 Example of Metric Engineering Drawing.

Where the preceding reasons are applicable, drawings should be dimensioned in SI, with conversions to customary units provided in chart form on the drawing. This approach will permit removal at some point in the future and will help the user of the drawing to become familiar with SI—since he must read the metric unit on the field of the drawing before he can locate the conversion. Figure 8 illustrates metric drafting practices, using the "chart method" for dual dimensioning.

Engineering Standards: Now, let us turn to the maintenance of engineering standards and documents. Engineering documents may be divided into three general categories:

1. General engineering specifications, including safety and environmental considerations: For materials, mechanical components, fluid components, electronic/electrical components, paints, surface treatments, lubricants, adhesives, etc.
2. Project engineering specifications: Specific product application documents, such as customer requirements which deviate from standard.
3. Quality assurance specifications: Interpretation of codes and regulations impacting on design, manufacturing, installation, and service.
These may be subdivided into foreign and domestic. Examples are: ASME codes, ASTM Standards, International Standards

Reference standards may also be subdivided into three categories:

1. Engineering tables, such as heat-transfer coefficient tables.
2. Calculations: dimensional analysis of engineering calculations ensures the integrity of SI equivalence in commonly used formulas.
3. Design graphics: changes impacting this area occur in (among others):
 - Drawing formats • Diagrams • Symbols • Dimensioning

Conversion to the metric system involves conversion of most standards. All measurement-sensitive portions should be examined and a determination made as to what should be done to express them in the metric language. This examination entails considerable interaction: company standards must be examined in the light of industrial standards, industrial standards must be examined in the light of national standards, these in turn require examination in the light of international standards. Ideally, the goal is that all should be in harmony in terms of technical content and time of availability of converted standards.

Before initiating a program for metrication of standards, a number of questions relating to each specific standards area must be answered; i.e.:

Should the standards:

1. Remain unchanged?
2. Retain customary data sizes and units with metric equivalents added?
3. Retain customary data and sizes with dimensions expressed in metric units only?
4. Adopt metric data and sizes with metric dimensions accompanied by customary units?
5. Adopt metric data and sizes expressed in metric units only?

By whatever means is chosen, a gradual, phased transition to suitable mix of soft-converted standards with numeric values expressed in metric units—and hard conversion, with standards conceived and developed in metric terms and modules, is desirable. This leads to an indirect benefit of metrication: the opportunity to reduce non-uniform, divergent practices in the development of standards.

Threaded Fasteners: Significant progress has been made toward the worldwide standardization of screw threads and fasteners. United States national standards consistent with International Standards Organization (I.S.O.) standards are in the latter stages of development for issuance as American National Standards Institute (ANSI) standards. Simplification and variety reduction are anticipated, since the new metric standards consist of a series of 25 diameter pitch combinations ranging from 1.6 through 100 mm. There will be two basic international screw thread systems for metric fasteners: one for aerospace fasteners (J' threads); another for commercial and industrial fasteners—both sets of standards eventually to be sanctioned and issued by I.S.O.

Rounding: Converting to metric units will require procedures for rounding. The necessary accuracy of a calculation of a toleranced dimension depends on the specific circumstance in which it is applied; therefore, any rules for rounding must be applied when the individual situation is suitable. A simple approach is:

Once the last significant figure has been selected and the digit that follows is less than 5, the last significant figure remains unchanged.

When the digits that follow the last significant figure are greater than 5 (this includes 5 followed by one or more quantitative digits) the last significant figure is rounded up.

When the digit that follows the last significant figure is exactly 5 and the last significant figure is odd, then and only then, the last significant figure is rounded up.

On the average, this yields as many figures rounded up as figures rounded down. Rounding to the nearest even number makes the arithmetic a little easier as well.

Implementation Activity

In implementing adoption of SI metric units, the Engineering function usually has a lead role and serves as a pacing activity for carrying out the overall Corporate strategy. A well-planned and effectively managed program can bring success in terms of a timely metric capability and a reasonably orderly, smooth changeover.

It is important to develop an understanding that: (A) the first metric product program should be used as an "entering wedge" for metric transition; (B) the first program should not bear a disproportionate share of the total long-term metrication cost; and (C) a planned metrication program should not be confined to direct product-generated actions, but should be aimed at gradual development of overall capability to interact with an increasingly metric-oriented external environment . . . and, to eventually achieve a level of full metric capability.

Figure 9 shows the metrication schedule prepared by a large research and engineering establishment at the outset of its program. It was to begin when approved and be completed by late 1977. Conversion of laboratory and pilot plant equipment was to start early in 1974 and be completed by mid-1976. Purchase and construction of new equipment with metric readout capability was to begin in 1974 . . . to achieve a full metric data capability by the end of 1976. For reports and documents, the schedule called for dual units beginning in 1974, and lasting through 1976—and a gradual transition to fully metric reports in 1976. In retrospect, the program has proceeded reasonably well, but the overall schedule slipped because of:

- Delay in adopting and implementing a national metric policy and other factors that led to slow progress in developing U.S. national SI metric standards.
- The need to maintain both customary and metric versions of design tools, etc.

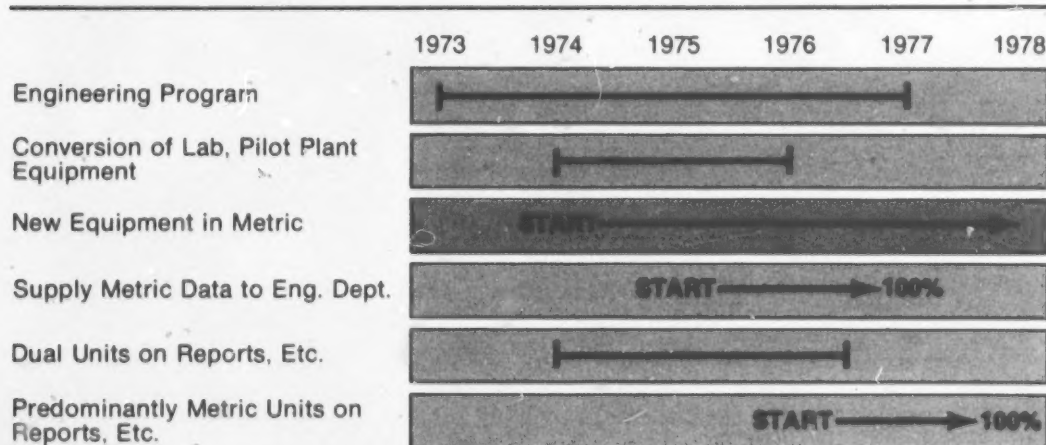


FIG. 9 Example of Research and Engineering Company Original Conversion Schedule.

Manufacturing

Impact
greater on
manufacturing
than any
other function

Metrication's impact is greater on manufacturing than on any other company function. Ultimately, as the transition progresses toward "predominantly metric" condition, or a "full metric capability," the effect becomes far-reaching. Virtually every aspect of the manufacturing function will be affected, not only by the company's metrication program—but also by the ongoing metric changeover of its suppliers and subcontractors. Following are capsule comments on some key aspects to be considered:

Training and Communication: Metric conversion implementation requires careful coordination of all departments within manufacturing, as well as close liaison with other functional areas, such as engineering, purchasing, and marketing. Manufacturing managers should ensure that line supervisors are briefed adequately—and, where necessary, trained to impart on-the-job training in metrication techniques.

Timing: The timing of metric changeover within manufacturing departments is a function of the company's overall metrication program. In addition, it is dependent on the availability of supplies, materials, machinery, etc. It is recommended that: (1) an analysis be prepared, planning the changeover to metric; and (2) joint discussions between design engineering, purchasing, manufacturing, and quality control areas take place at an early stage in the development of a metric product. This is required so that lead time is allowed for acquisition of machines, tooling, equipment, and inspection devices, and for accomplishing whatever training is necessary.

Costs: Metrication costs should be kept in mind when preparing manufacturing budgets. Principal cost factors will be: the conversion of some machinery, equipment, tools, training of labor, increase in storage space, dual stocking of customary and metric materials and components, and, in time, perhaps the increasing cost of supplies in customary units as metrication proceeds.

Rationalization: A by-product that can partially offset metrication cost is the opportunity to rationalize: not only variety reduction in materials and parts, but also by sweeping aside outdated methods and procedures and introducing modern production techniques.

Identification: In many instances, it has been found useful to identify by color coding or other means, metric components, tools, and machines.

Planning and Estimating: Metrication may cause the rewriting and, in some cases, the rethinking of planning sheets and routine instructions. Changes can result from the use of materials such as bars and sheets in metric stock sizes, where machining and cutting allowances are different. Careful attention should be paid to metric impact in certain departments such as sheet metal working and fabrication. Their operations should be carefully planned, and new cutting instructions provided, to avoid operational problems and material wastage.

Product Tooling: A survey of subcontractor's plans should be conducted, to ensure that metric requirements are not placed on firms whose capabilities are inadequate. In many instances, new tooling for new metric products is produced to metric standards. In other cases, the tooling has been designed and produced to customary measurement units and standards, with accommodation for interface with metric product dimensions. In either case, close liaison is required with any subcontractors who are producing components from tooling supplied to them, and with vendors who are supplying tooling from which components are to be produced.

Plant Maintenance: There is need for a well thought-out plan to cover the phase-in of metric capability with acquisition of new machines, and to determine the possible need for converting some existing machines. In addition, there will be need to replace some maintenance tools and equipment, and to acquire metric small tools and measuring equipment. Factory services will be measured and metered in metric units—and the conversion and recalibration of metering and indicating equipment should be considered.

Production Machines: It is essential to plan future machinery requirements and replacements over a period of time sufficient to cover at least the complete product metric transition.

NEW MACHINE: In general, any new machines purchased should have dual readout devices, or be capable of converting to dual readout. At an advanced stage of metrication, new machinery will be acquired with metric-only capability.

MACHINE CONVERSION: When considering the possible conversion of existing machines, life expectancy of the machine should be taken into account. Conversion cost need not be incurred, if the machine is due to be replaced in a relatively short time. In deciding whether to convert or replace, these factors should be considered, along with "key questions" on p. 22:

1. Delivery time for new machines
2. Delivery time for conversion parts and time needed to perform the conversion
3. Life expectancy following conversion

Where machines are to be modified, a survey should be carried out for each separate piece of machinery and equipment, to identify specifically which of its capabilities are, in fact, used in current manufacture.

In some machine tools, particularly those that are required to work to a high degree of precision, difficulty following conversion to metric may be encountered due to wear in components other than those replaced as part of the conversion. It is recommended that these aspects be carefully evaluated before embarking on a costly conversion program.

Machine Accessories: Although it ultimately may be necessary to replace machine accessories (for example, collets and arbors) with metric items, it is important to realize that the time of change must be matched with availability of raw materials in the metric sizes. Initially, in many cases, it has been necessary to machine metric parts from inch stock. Most machine accessories should be replaced when standards for raw materials and stocks are converted to metric.

Small Tools: Metrication brings an opportunity to standardize on preferred metric sizes; and the specification of metric specials should be avoided. Although small tools are consumable, metric phase-in should be carefully implemented to minimize cost of double stocking and added storage requirements.

Quality Control: Engineering drawings usually note that the metric dimensions are "primary" and that any form of inch conversion is provided "for reference." This means that inspection and test specifications are to be written in metric terms for new metric products. Where existing products are redesigned for metric production, inspection and test specs also should be rewritten, and any special test equipment should be adapted as necessary.

Inspection Standards: Manufacturing departments that have a standards room should make plans to obtain new metric standards. During the transition period, it will be necessary to maintain both customary and metric standards.

Inspection Equipment: The requirements for inspection equipment should be determined at the same time as the purchase of the machine tools that will produce the first metric products. In general, the comments already made regarding plant and equipment replacement and conversion also will apply to inspection equipment. Some inch measuring and gaging items can be converted to metric by recalibration, for example, air gages and mercury gages. Other items may be converted by replacing certain parts. The advice of the manufacturer should be obtained before expensive devices are replaced. It is, of course, important to consider life expectancy of equipment when making the metrication decision.

Conversion Tables: Metrication should be planned so that machine equipment and measuring equipment using the units specified on the drawings are available, both on the shop floor and in the inspection departments. Conversion from inch to metric or vice versa must not be left to the operator or inspector. For these reasons, the use of conversion tables on the shop floor and in inspection areas should be discouraged.

Stores & Stock Control: During the metric transition years, it will be necessary to carry stocks of both customary and metric items—hence, it is suggested that some clear means of stock separation and/or identification be developed and used. Some customary (inch) items eventually may become obsolete as a result of metrication. It is good practice to maintain stock valuation accounts separately for customary and metric stocks, so that the extent of stockpiling of customary items can be monitored closely during the transition period.

STOCK CONTROL: Stocks of inch items should not at any time exceed quantities required to complete existing contracts or authorized production runs for existing products. It is realized that some existing products may remain in use for a number of years. Obsolete and slow-moving items should be disposed of to make room for receipt of metric materials and parts.

STORES: A number of important decisions must be made:

1. Total segregation of metric work from inch work, which probably would require added storage facilities.
2. Complete segregation of raw materials, components, and standard commercial items in all stores and work in progress.
3. Purchase of storage equipment, bins, handling facilities, etc.; opportunities must be taken to effect a general improvement in stores efficiency at this time.
4. Clear and uniform identification of metric parts, particularly in instances where a metric item is not obviously different from its inch counterpart.
5. Metric measuring and weighing equipment in goods received departments is to be ordered and installed prior to receipt of metric supplies.

Metrication Impact on manufacturing

Some Key Questions:

- Which plants will be involved?
 - What machines will be affected?
 - What is the remaining useful life for each machine?
 - What must be done to enable it to produce a metric part?
 - Is it worth modifying, or should it be replaced?
 - In purchasing a new machine, how best to provide dual capacity.
 - Can newly designed metric parts be produced on existing machine tools?
 - To accommodate the metric new product program, is it necessary to accelerate the normal planned replacement schedules for production machines?
 - What is the current availability of metric machinery and equipment?
 - What rationale will be used for cutting tools and plant consumables?
 - What new measuring and inspection items will be needed for production and quality control?
 - What will be the effect on capital equipment budgets under various alternative approaches toward metric working capability?
-

Purchasing

Purchasing department should be brought into policy implementation

To avoid unnecessary cost penalties and maintain continuity of supplies, the purchasing department should be brought into metrication policy implementation at the beginning. This is particularly important because metrication will probably increase delivery times for some items.

The buyer should be given firm planning dates for the initial production of metric products, to allow for sufficient lead time:

1. To identify stocks of each item and raw materials
2. To locate and evaluate sources of supply
3. To arrange for new tools to be ordered, made, and tested
4. To secure batch quantities

Buyers must progressively obtain supplier's and subcontractor's programs, dates for machine tool conversion, materials availability, etc., and ensure well in advance of new metric product introduction that vendors and subcontractors can meet their commitments.

Buyers should continuously obtain and maintain lists of all purchased materials, both in components and fastenings, to metric standards, and ensure that copies of these standards are forwarded to engineering, manufacturing, and other interested areas.

Metrication Plan

Following is a digest from the metrication plan developed by a purchasing department in a large manufacturing company:

Purchasing Department Metrication Plan

Purpose: This plan was prepared in response to the request of the company Metrication Coordinating Committee, to serve as a guide for Purchasing activity required to accomplish transition to the SI Metric System.

Objective: Define basic requirements of a Purchasing Department metric conversion plan that will support orderly, properly time-phased, and cost-effective transition to the SI metric system, envisioned in Company Policy x-xx dated September 13, 197x.

The Purchasing Dept. plan should be consistent with and support the Company Metrication Product Plan, the equipment requirements and plans of manufacturing operations.

It should also recognize the status of metric conversion in the automotive industry, as well as progress being made by competitors and suppliers.

Scope: The scope of this plan will include all Purchasing activities associated with the procurement of parts and assemblies, raw materials, and tooling and capital equipment required to support the production of all United States designed and built products and components.

Strategy: This plan is intended to help achieve the Company goal of conversion to the SI Metric System by the mid 1980's in a manner which is consistent with overall company interests and minimizes cost and disruption in the product program. Purchasing's activity will observe the general direction endorsed by the Company Metrication Coordinating Committee, which will result in following closely the conversion trend set by industry and the federal government.

The plan will outline Purchasing Dept. action required in support of the company metrication effort, both in terms of internal action required within the Purchasing Dept., as well as the communication and interaction necessary with suppliers.

This metrication plan, together with those of the other functional areas of the company, will comprise the overall Company Metrication Plan. The Company Plan will serve an internal purpose . . . and also may be used to provide evidence of a planned, voluntary metric conversion, which can be furnished to the U.S. Metric Board as they proceed to implement the Federal Metric Conversion Act of 1975.

Product Metrication Plans: The first major step in company metrication was the decision to use the SI Metric System as the primary means of designing and dimensioning the new 1977 product line. The 1978 model xyz likewise will be predominantly metric.

Beginning with the 1979 program, all new product and component programs will be metric, unless specific exception is authorized by management for functional or economic reasons.

This position recognizes that in a primarily metric product, it may still be advantageous to retain a limited number of carryover components that are non-metric. However, the primary direction of new product programs from this date forward will be to use metric dimensions.

Conversion Charts: A current Engineering directive, Procedure ABCD, requires the use of metric-inch conversion charts applied to the body of metric drawings. These charts were introduced for use in the period of transition to the metric system, and were intended to prevent supplier conversion errors. However, if retained too long they can serve as a crutch to suppliers who are slow to accept metrication. In view of the current Company Metrication Product Plan, conversion charts should be omitted from new drawings beginning with the 197x model year releases, unless specifically requested by Purchasing or the supplier.

Schedule:

I. PERSONNEL AWARENESS & TRAINING

July 1974	Management briefing
Jan 197A	Prepare Metrication Plan
— 197B	Decide training program
— 197C	Begin training

II. SUPPLIER COMMUNICATION

1. Parts & Material Suppliers

Feb 1975—Conducted supplier sampling survey on metric capability and plans.

— 197A—Sent letter to suppliers, informing them of our plans.

— 197B—Additional phone surveys, to determine supplier metric readiness.

— 197C—Sent update letter to suppliers regarding company metrication plan and schedule.

2. Capital Equipment & Tooling Suppliers

Metrication progress with regard to the procurement of metric machines and tooling will be dictated by schedules established by the Manufacturing Dept. Manufacturing operations desire to implement transition to the metric system on a gradual basis which will minimize cost and disruption to manufacturing activities, and avoid obsolescence of usable equipment strictly for the sake of accomplishing conversion to a forecast schedule. Close communication between manufacturing, buying personnel, and the machine tool industry will be the key to assuring a smooth transition at the proper schedule. Because of the sizeable investment in much of the equipment, its relatively long service life, and the fact that metric parts can normally be produced with relative ease off non-metric machines, it is anticipated that metrication in this area will probably lag the product line changeover.

At the present time, many new equipment purchases either require dual-dimension capabilities, or are being designed so that conversion can be accomplished at a later date if required. Electronic digital readout equipment currently is being procured with either metric readout or with conversion capability. It is anticipated that the company inventory of metric-capable equipment (either dual-dimension or metric only) will grow steadily during the next decade, driven by our product line conversion, but tempered by the machine tool industry's pace in accomplishing the metric transition.

III. DATA PROCESSING CONVERSION

Data processing conversion to the SI Metric System is being coordinated by the Systems Department. The Purchasing interface with this department is provided by the Purchasing Systems & Procedures Dept.

A number of Purchasing Dept. computer files and files that interface with Purchasing files will require conversion as metric system usage becomes more prevalent, and other forms and identification labels likewise will require alteration.

The general approach to conversion in this area will be to undertake the changeover at the approximate time that the number of metric parts equal the number of non-metric parts which remain in active file. As the changeover period becomes more imminent, consideration will be given to the maintenance of dual files (e.g., pounds and grams) if it appears that this represents a practical way of assuring a smooth transition.

Among the areas that will be subject to close scrutiny to determine the optimum schedule and method of conversion are:

- Part weight file
- Identification labels
- Packaging forms
- Unit of measure code applications

Implementation: It is difficult to accurately predict in detail, not only all of the actions that will prove necessary over the next several years, but also the schedule to which the events should occur. However, to serve as a basis for subsequent planning of our metric conversion, the schedule of target dates shown in the foregoing plan has been established.

Periodic progress reviews will be made to update plan content and schedule as necessary.

General Comment

Turning now from a representative Purchasing Dept. Metrication Plan (pp. 23-25), to further generalized observations: It has been found that in some companies—depending upon their place in the "maker-seller-buyer" chain—the purchasing department is the first area affected by the metrication trend. The purchasing agents thus can function as "advance scouts" for the metrication effort.

Once alerted to the onset of metrication, Purchasing managers, generally, work with their suppliers to:

- keep them informed of plans and requirements
- participate, as necessary, in establishing the broad framework for mutually workable changeover plans
- foster growing metric orientation in business dealings
- encourage a long-term viewpoint in conducting the metric transition

Eventually, benefits may be anticipated, but metrication does call for extra effort by the purchasing manager. During the transition period, difficult decisions must be made. Some price comparisons will be complicated by slight dimensional and physical property changes due to adoption of metric standards; and, even for comparable items, price analysis may need to account for cost of phasing a metric part into the system . . . or potential cost penalty from retaining an inch-module item that eventually may incur added cost. Early metrication experience has led some purchasing agents to further advise that:

- Quality and value may be more difficult to evaluate and compare.
- Delivery schedules require thorough discussion and effective monitoring.
- Supplier capability is a matter that requires active concern and realistic assessment.
- Inventory will, in some instances, be a special problem.

Again, in the Purchasing function as elsewhere, proper planning is crucially important as a tool for minimizing (or optimizing) conversion cost and obtaining long-range savings and benefits. The Purchasing metrication plan should have concurrence of overall operating management. And a strong foundation of good, up-to-date information on metrication is vital to the economic impact assessment and competent planning for Purchasing's involvement in the process of metric changeover.

Marketing

INDUSTRIAL PRODUCTS

Certain principles apply to metric conversion in all companies, in any industry. However, metric conversion implementation and its effect on marketing will not be the same in any two companies in any industry. To set the stage for development of a marketing metrication plan tailored to a particular company, it is well to review some fundamental aspects of metrication as they relate to marketing.

The first is that commercial or marketing facts and judgments are decisive factors in metrication decisions—from establishment of a company's basic policy, to its detailed planning and implementation.

The second is to understand clearly the full importance of the three basic questions on metrication: (1) Whether or not to do it? (2) When? and (3) How?

The first question has, in effect, been decided—because, in the long term, it is unlikely that an organization can effectively isolate itself from the ongoing national metrication trend in this country.

The second question (when?) then moves to the forefront. This resolves itself into decisions of timing in serving your customers most effectively and in avoiding unnecessary cost during the metric transition. In many instances, the timing question is settled when major customers specify that they want metric products.

Other enterprises, however will not find the "when" question resolved in such a straightforward manner. They must ask themselves some hard questions: How sensitive are our customers and markets to metrication? What are their conversion plans? How will the voluntary aspect of U.S. metrication affect our markets?

Marketing must provide sound, factual input on which to base this management decision. Generalities or metrication platitudes can misdirect the timing decision, resulting in increased conversion costs and timing problems. Each company must resolve this problem based upon its own individual position. When action is taken, it should be based on well-informed market analysis.

The last metrication question (how?) is primarily a technical one, and other sections of this book contain information that should be helpful.

The third fundamental aspect of metrication as related to marketing is the point that, in the United States, metrication is to occur voluntarily. It is especially important to perceive the impact of "voluntary" on the conversion process. Essentially, voluntary action is paced by market-driven change—which makes the timing of your own actions critical.

Assess Metrication and Your Markets

Studying the effects of metrication on marketing is useful for guidance purposes. Generalizations, however, will not suffice. The assessment must be brought into focus. We are dealing with specific products and specific markets that require specific plans and actions. Orienting these products and markets to metrication is, therefore, essential.

The first step often is an objective review and update on metrication progress—worldwide and in the United States. An overview of where we are, how and why we got there, and how fast the trend is moving, provides background for more detailed study of industries and markets of principal interest to you. It is important to learn precisely what is occurring: what is the status of your key customers and markets with respect to metric conversion?

The market analysis can lead to development of marketing plans for metrication—covering all sales-related phases of the conversion, from publicity on formulation of a corporate metric policy, to implementing technical service on the new metric products.

Voluntary
action is
paced by
market-driven
change

Metriation Effect On Marketing Functions

In a broad consideration, one could assume that metriation would not affect sales, market research, sales promotion, advertising, or other marketing functions. This viewpoint would be based on the idea that a metric product can be considered simply as a new or modified product. On this basis, all that is needed is a marketing plan to move the product to the consumer or end user effectively.

This is, however, an oversimplification—because there are some unique marketing problems caused by metriation. One of the impacts that affects all facets of marketing is the need for careful, detailed planning. It's true that might be said of any marketing plan. But, in metriation, there is the special situation, since customers typically are on a learning curve associated with a new "language of measurement"; and, in many instances also are assimilating related changes in long-established standards and specifications. The many ramifications need to be identified and understood. That is why there is emphasis on studying all basic aspects of metriation and their attendant problems. Metriation does not really complicate marketing—but, it does demand careful consideration of its uniqueness in the current marketplace.

Let us now briefly examine the individual marketing functions, and note how metriation directly affects them:

Market Research and Development: Metriation heightens the importance of these regular functions. It is worthwhile to emphasize the necessity for market research and development to provide a continuous flow of market information. Metriation in the U.S. is in a fluid state. Trends are beginning, and growing, and shifting. In view of this, metriation planners in marketing need accurate and current information to guide their efforts in converting to SI most effectively.

Sales: The first assignment for sales planning groups and the field sales staff is let your customers know where you stand and what you intend to do. How and when this is done depends upon the sensitivity of each market segment to metriation. One of the most important effects of metriation on sales relates to communication with the customer in a new and different measurement language. Careful thought must be applied to all steps from receipt of the order, to processing, and billing.

Technical Service: This arm of the marketing team serves to keep the customer satisfied, by assisting with solution of day-to-day problems and by advising on effective use of your products. As metriation progresses, there will be problems—real and imaginary. Your technical service representative can provide information to forestall problems, and, when necessary can be a source of guidance for resolving problems that do occur. Obviously, to fulfill this role, the service representative must have a thorough understanding of metriation.

Publicity, Promotion, Advertising: The impact of metriation on these marketing units can best be described as a challenge to exploit metriation in the most effective manner. There are opportunities to use these functions in your metric marketing plans. How and when depends upon your customers' sensitivity to metriation. However, it is evident that, for some time to come, significant metric activities will continue to be newsworthy.

CONSUMER PRODUCTS

The foregoing material has been oriented toward industrial marketing. In general, in regard to direct consumer marketing (retail)—the key precept is to communicate with your customers and with the general public in a "measurement language" they understand. This means that careful attention should be paid to numeric values: timing metriation to keep pace with growing public awareness of SI metric units... so that measurement units, per se, will interpose no difficulty in the normal ways of buying, using, and servicing your products.

It is recognized, generally, that national metric conversion will progress more easily and smoothly, if consumers are informed, and participate, and understand the conversion process.

Many areas of impact will be felt by the consumer: areas such as product packaging and labeling, clothing sizes, education, cooking, weather information, and various aspects of personal and public transportation. Individual customers, and the public at large, will need to be assured that they are getting fair value for their money as the U.S. goes metric.

For the consumer, metric conversion is a trade-off of possible benefits and improvements versus possible inconvenience and expense. Although most companies expect eventual economic benefits from metric conversion, there are some short-term costs involved. In some instances, these added costs must be passed on to the consumer.

Why Consumers Need to be Concerned

One common problem for nearly everyone will be learning to "think metric," and to visualize and estimate in metric terms as we now do in customary measures. There is a potential for deception and abuse during the transition period. Consumers are concerned and have a vague fear of this, although they aren't sure what form it may take. Also, there is the likelihood that some people will feel they are being exploited (or cheated), when in reality they are not. The thoughtful manager of metrication will need to give adequate attention to these consumer concerns, and make plans for dealing with them.

The need for consumers to understand and participate in metric conversion is important for two reasons: (1) to assure that consumer needs and wants are made known and considered by those who make decisions relative to metrication and marketing of consumer products; and (2) to create a climate of acceptance on the part of consumers and a feeling of confidence that metrication ultimately will benefit them.

There are some important areas of consumer concern that must be addressed with a genuine interest and empathic attitude. To allay customer fears and sustain a perception of fair treatment, consumer product manufacturers and retailers should carefully plan the metric product size, quantity, package, label, pricing, advertising, sales and service practices.

It is important to realize that metrication will not be accepted "automatically" by the general public and by consumers . . . and that metric product marketing strategies and plans should take this into account—since without consumer acceptance, the changeover will take longer, cost more, and be less beneficial than would be true if consumers understood and accepted the program.

Consumer acceptance of metric conversion cannot be taken for granted. Careful planning and timely, accurate information are crucial factors in preparing consumers to understand and accept the changes they will encounter. Some have called this the "people changing" aspect of metrication.

Experience in Canada and other countries led to the marketing guideline that, whenever possible, package size should be moved up, rather than down. This general approach to "hard conversion" packaging of consumer goods is helpful in avoiding a charge that metrication has been used as a way of increasing price.

The cardinal rule is: when pricing the new metric size package, cost per unit quantity (of the product) should not be higher than cost for the same quantity in the former non-metric package size.

Figure 10 is a consumer aid that shows price per kilogram and equivalent price per pound. This type of chart can be used to provide the consumer with point-of-sale information on unit pricing, and allay the fears of a "hidden price increase."

METRIC PRICE GUIDE					
price per lb cents	price per kg cents	price per lb cents	price per kg cents	price per lb cents	price per kg cents
0	0	1.00	2.20	3.00	6.60
5	1.10	1.05	2.31	3.05	6.71
10	2.20	1.10	2.42	3.10	6.82
15	3.30	1.15	2.53	3.15	6.93
20	4.40	1.20	2.64	3.20	7.04
25	5.50	1.25	2.75	3.25	7.15
30	6.60	1.30	2.86	3.30	7.26
35	7.70	1.35	2.97	3.35	7.37
40	8.80	1.40	3.08	3.40	7.48
45	9.90	1.45	3.19	3.45	7.59
50	11.00	1.50	3.30	3.50	7.70
55	12.10	1.55	3.41	3.55	7.81
60	13.20	1.60	3.52	3.60	7.92
65	14.30	1.65	3.63	3.65	8.03
70	15.40	1.70	3.74	3.70	8.14
75	16.50	1.75	3.85	3.75	8.25
80	17.60	1.80	3.96	3.80	8.36
85	18.70	1.85	4.07	3.85	8.47
90	19.80	1.90	4.18	3.90	8.58
95	20.90	1.95	4.29	3.95	8.69
100	22.00	2.00	4.40	4.00	8.80

FIG. 10 Metrication Unit Weight Price Chart, Pounds to Kilograms.

Computer Systems

A phased approach is necessary

Before beginning to plan conversion of computer operations, it is necessary to acquire a working knowledge of the SI metric system itself. Next, comes consideration of the computer system. This consists of hardware and software. Hardware is the "machinery": the computer, memory devices, printers, etc. Software is the program that drives the computers, to accept input, process it, and produce output.

In practice, a phased approach to computer metrication is necessary. It is recognized that certain aspects of metrication can be done sooner than others. There are various areas within a computer system that meet these requirements.

For example, implementation of dual Systems of Measure logic can be done independently of other events. Most analytical work in developing adjusted field sizes and format and transactions variations can be based on product specifications and the company metrication guidelines. Mathematical computations may be simulated in advance, for early problem identification. Activities such as these comprise one phase of metrication.

Another key consideration is coordination of SI metric support with the using functional areas. For a smooth changeover, two essential elements are training and a plan that is mutually agreed upon by involved areas.

Within process automation systems, there is need for a combined effort by the systems and manufacturing engineering organizations who will modify process equipment to accommodate SI metric or obtain equipment with metric capabilities for use in the manufacturing processes. Decisions may be made on a subsystem basis to change to SI metric in specific areas of a process or a warehouse or a billing and ordering system. In many cases, changeover to metric may await introduction of a specific metric product, new technology or equipment, or development of a new computer system.

Conversion of Computer Operations

Conversion of computer operations will require changes in both hardware and software equipment. Although the basic computer itself is unaffected, there is some impact upon input/output devices, which will need different character sets: uppercase, lowercase, Greek characters and certain new symbols. Instead of changing character sets, many firms are using approved alternate symbols based upon ANSI Standard X 3.50-1976 Representations for U.S. Customary, SI, and Other Units to be Used in Systems with Limited Character Sets (which is consistent with the international standard ISO 2955-1974, Information Processing.)

The area of software, especially input programs and the output, will be most affected by the metric change. There are several reasons for this impact:

1. For a long time, we will be working in a dual inch/metric environment. There will be need to have both measurement units on the same document in already existing columns or fields. (A typical process document, shown in Figure 11, illustrates the use of extra lines for information for dual measurement and also the extra columns for unit of measure code.)
2. Some previously used programs already carry both metric and customary (inch) measurement units. These present a problem, because portions of the old metric usage do not conform to accepted SI practice.
3. Measurement conversions from either system to the other create another field requirement problem. Conversions from inch to metric result in a need for more fields on the left side of the decimal point; i.e., 39.37 inches = 1 000 mm.
4. Numerical control equipment and graphics design equipment, because of internal circuitry design, are converted readily by writing a routine for the post-processor.
5. Computer mathematic equations will have varying degrees of impact. Routines can be written into existing programs to handle much of the conversion. But many programs will need considerable modification and/or rewriting.

6. Considerable thought should be given to the need for converting historical data to metric measurement for comparison purposes. In many instances, when this is necessary, it may be done with a simple desk calculator. Data storage and retrieval systems—inherently are "measurement sensitive." Every data processing system that handles measurement-sensitive data will be affected to some degree. Systems that store and generate such data for use in forecasting, statistical analysis, or other analyses, will have a major discontinuity in their historical data. For example, cost accounting systems will generate unit costs per kilogram or cubic meter—while all previous data are in cost per pound or cubic yard.

The use of one master program to convert all computer programs to metric could result in loss of design integrity and lead to errors in rounding. On the other hand, if it is decided to convert in the core (instead of with one program translation on input/output devices), there might be a problem finding core storage space for the additional information. Rounding error resulting from conversion of measurement units should be analyzed and handled according to authoritative rounding rules, as appropriate for each situation. Computer programs can be written to use "limit" dimensions and perform all rounding "inward" (within original tolerance)—thus preserving design integrity and assuring interchangeability. Care, however, must be exercised, to avoid excessive "tightening" of manufacturing tolerances, with the resultant effect on cost.

There is need for an extensive systems analysis to determine overall impact of conversion. This analysis should include the following considerations: overall time of the conversion program; coordination between systems and functional using areas; and cost estimates.

In sum: problems to be faced are: computer calculations; storing, using, and comparing historical data with current or new data; correcting rounding errors caused by conversion; modification of computer design; and dual description of parts and products on bills of material, process routings (Figure 11), inventory listings, and other documents. Items such as gages, inspection aids, readouts, standards, and conversion of coordinate systems must be introduced in phase with system development.

A key point in the changeover involves cooperation between the system developers and using areas such as product engineers or manufacturing engineers. The users, rather than systems people, should accept responsibility for the needs survey—because they will be more aware of the effect of metrication on day-to-day computer operations. A successful changeover will result, if these two groups recognize their interdependencies and work together.

BATCH GRP	UNIT	TR	C STD	TIME	CLASS	DESCRIPTION	R	YORK/RAW UNIT/ MATERIAL NO.	QTY	UNIT	UNIT/HR	EST UP	A
000	01					RAW MATL	0	04-311000P33	000		0.000		
010						01-000 ALUM	0						
000						00-000 (1.700 IN) DIA	0						
000						00-000 (1.110 IN) DIA	0						
000						PER PC	0						
100						011000 000 00 0.000	0						
OPERATION: 0000 DEPARTMENT: 0000 CDOPT: DVLPP: OFSTY: + 000 USE CODE: 00													
BATCH GRP	UNIT	TR	C STD	TIME	CLASS	DESCRIPTION	R	YORK/RAW UNIT/ MATERIAL NO.	QTY	UNIT	UNIT/HR	EST UP	A
010	00	01	L	0		R END OUT-FACE SPOTDR	0						
010						DOWN-REAM 12.75 DIA	1						
000						10000 IN TO 10-40 DIA	1						
000						PLUS 0.0004 DIA (.400)	1						
000						PLUS .001 IN)-TURN 60	1						
000						TO PLUS DIA PLUS 0.0000	1						
000						0.0000 DIA (1.620 PLUS	1						
010						00000 .000 IN)-DRK COR	1						
000						000 0000 LARGELY-POSS	1						

FIG. 11 Dual Measurement Process Document.

Training

Metrication
should be
conducted
in a
low-key
manner

There is a wide variance of views on metric training. Some people say none is needed. Others advocate training everybody. Many firms attempt to tailor the training program, with close attention to the three main factors: who . . . what . . . and when to teach or train.

A composite description of the rationale used by many companies would indicate that: They attempt to keep employees informed on what is occurring in metrication, but actual training is a different matter; handled quite selectively. Viewed strictly in terms of "measurement-sensitive" aspects of the job, many employees require no metric training at all. Nothing happens to their jobs as a result of going metric. They encounter no change in what they are doing. For the rest: "We train only those who have a need to know, only what they require to perform their job; and train them shortly before they will use the new knowledge."

Attitude

Important to metric transition progress is a strong attempt to retain and emphasize a "business-as-usual" attitude. This matter-of-fact atmosphere helps dispel fear of the unknown and reduce inherent resistance to change. Metrication should be performed dispassionately; as devoid of emotion as possible—and should be conducted in a low-key manner. Undue attention drawn to the metrication effort can create problems where none should exist, and become a negative factor in working against the balance needed in striving for a progressive yet stable situation.

One key area in which the above-described tone and low-key emphasis should be earnestly sustained is metric training. Some firms have found that a massive program in which many people are subjected to broad training can be quite costly, and even detrimental to progress. These experiences, augmented by the advice of professional trainers and educators, led to the widely held view: that training should be done at a gradual pace, accommodating only those needing the information during the transition . . . and, most importantly, imparting only the amount of training needed by the individual to do his job. For most employees, it is not necessary to learn the entire SI system. Indoctrination covering the entire metric system in general terms is, however, quite beneficial and should be included early in the program.

Training people on a gradual and minimum basis may be considered as one of the "keys" to a successful metrication program. This has evolved as a recurring recommendation from experience of many firms in the United States and abroad. Many companies have found that their transition toward full metric capability has progressed smoothly with minimum problems, using a low-key training approach. People seem to adapt and react cooperatively if they are not rushed into something new and strange. The precept seems to be: build upon what is already known, and adaptation follows quite naturally.

Approach

Successful metric training will depend to a large extent upon the support given by management. Management commitment is required early in metric transition to provide direction and resources to the training department.

Once a metric conversion schedule has been established (what products? when?), the training manager can establish a starting date for metric training. With this in mind, a metric awareness program should be started, to inform employees of the impending change. This awareness phase, if properly administered, can do a lot toward reducing resistance to change.

The training department must now define the learner population and identify the actual metric training needs. A properly prepared needs analysis can do much to reduce training costs and the time required to complete the program.

When the learner population has been defined and the metric training needs determined, a decision must be made as to the method(s) of instructions. Small groups of people requiring a minimum of training may call for classroom lectures, while large groups requiring in-depth metric training may require a more expensive and sophisticated approach, such as programmed instruction or videotapes. On-the-job training may be the logical approach for other

groups. At this point, an estimate should be made of the time and funding required to complete the training. This should be agreed to by the metric committee prior to actual program development.

Once approval has been received, development of the programs should begin. Different programs will be required for different segments of the "population." By careful structuring and a little manipulation (using the needs analysis data), certain portions of the training program can be reduced or expanded as needed, so that a basic program will fill the needs of a relatively broad section of the learner population. For example, almost everyone should be exposed to at least an introductory program covering the most commonly used units of the metric system. This unit of training could then be made the first of a series of training modules covering other metric units in more detail. A student would take only those modules identified by the needs analysis data. The number of training modules required and their instructions/content can be modified to fit the exact learner population, to ensure that each student receives the proper level of instruction.

It is imperative that each student be trained just prior to his or her actual on-the-job need. Training too soon is almost as bad as training too late. This sounds simple, but, in fact, can be difficult. If your company, like most companies, is planning to convert to metric only on new product programs, then you have a focus for the training program. When everyone on your first metric product is trained, you will need to train additional personnel as they receive assignments to that program. In addition, as other new metric products are started, the people on these new programs must also receive timely training in metric units. Schedules for employee training can be keyed to the product program master timing plan, since engineering and drafting personnel must be trained during the development phase of a new product, while manufacturing and sales personnel will require their training just prior to production or introduction of that same product. Metric training is not a one-time thing, but a continual effort that could conceivably last for most of the transition period. This must be taken into consideration when determining the method of presentation. The costs of a "canned" program can be prorated over several years, actually saving your company time and money compared to continuous classroom lectures.

Define Learner Population

Before you can start metric training or training development, you must determine the learner population. Obviously, different jobs will have different metric training requirements. Before establishing the actual requirements, you should break down potential students into some kind of categories, usually by job category or job title. A typical breakdown might be as follows:

- Nontechnical clerical
- Technical clerical
- Draftsmen
- Technicians
- Engineers
- Technical management
- Middle management
- Foreman/Supervisors
- Machinists
- Tool and die makers
- Quality Control personnel
- Sales and Service personnel

This list can be modified to fit your particular company or area of responsibility. In any event, such a breakdown is required to perform the next step, which is needs analysis.

Determine Metric Training Needs

A properly prepared needs analysis is a necessity if you are going to conduct a successful metric training program. The object, of course, is to train only those people who require metric

training, in only what they really need to know to perform their job, and to accomplish the training in a timely manner. By analyzing specific job categories and eliminating tasks that are not affected by metric practices or measurement, you can establish the core of metric knowledge required for each job. Using this information, selected group interviews can be conducted to further refine your data.

	Nontech Cler	Tech Cler	Draftsmen	Technicians	Engineers	Tech Mgmt	Mid Mgmt	Foremen/Supv	Machinists	T and D Makers	Qual Ctrl	Sales/Serv
Seven Base Units—Overview												
Meter—Overview												
Meter—In Depth												
Kilogram—Overview												
Kilogram—In Depth												
Second—Overview												
Ampere—Overview												
Ampere—In Depth												
Kelvin—Overview												
Celsius—Overview												
Celsius—In Depth												
Mole—Overview												
Candela—Overview												
Candela—In Depth												
Liter—Overview												
Liter—In Depth												
Radian—Overview												
Radian—In Depth												
Steradian—Overview												
Steradian—In Depth												
Multiples and Submultiples—Overview												
Common Usage—Multiples and Submultiples—Overview												
Common Usage—Multiples and Submultiples—In Depth												
Common Derived Units—Overview												
Common Derived Units—In Depth												
Derived Units—Overview												
Derived Units—In Depth												
Symbols—Overview												
Symbols—In Depth												
Micrometer												
Vernier Caliper												
Dial Indicators												
Reading Engineering Drawings												

FIG. 12 Needs Analysis Matrix of Metric Units.

This needs analysis can now be plotted on a matrix of metric units, terms, symbols, etc. to determine commonality of training requirements across different jobs. An example of a matrix is shown in Figure 12. This will establish a fairly comprehensive picture of metric training needs for your organization.

Using the information checked in the chart, you will see that, for this example, there are seven items that are needed in every job category. This would indicate that a metric training program consisting of these seven topics would be applicable to everyone. This then, could be the first module of a multimodule training program. Eventually, additional modules would be added to cover the needs of everyone.

Establish Training Method

Having defined the learner population and their metric training requirements, you are ready to select a method or methods of actual training. If you have a fairly large group to train, or if the training will be conducted over an extended period of time, it may be advisable to use programmed instruction techniques or videotape. Relatively small numbers of students might dictate classroom training using standard teaching methods. Other segments of the learner population might better receive on-the-job training, particularly where only a limited amount of knowledge is required.

You may find that there are programs already developed and on the market that will fill some or all of your metric training needs. For example, there are several commercially available programs covering the rudiments of SI metric and explaining the use of a metric micrometer and/or vernier caliper.

Whatever materials you decide to use, make certain they are technically sound. With the large number of training packages on the market, this is no small task.

Summary

Metric training can be successful if it is well planned, systematically followed, and has management support. In review, the following steps should be taken:

1. Gain management commitment
2. Establish training schedule
3. Begin awareness program
4. Define learner population
5. Determine training needs
6. Determine training method
7. Estimate time and costs
8. Obtain metrication committee approval
9. Prepare the training program
10. Conduct training in a timely manner

Figure 13 shows an example of metric awareness poster and cartoon material, for familiarizing people with Celsius temperatures.



25 Degrees Fahrenheit



25 Degrees Celsius

FIG. 13 Example of Metric Awareness Material.

Cost

In normal good business practice, managers want to know the projected cost of programs they are considering. This is understandable. Usually, such information is used to control, justify, recover, or offset costs.

The paradox, however, is that metrication cost is not susceptible to management and control by techniques that entail quantifying all elements of cost. Metrication costs are much-discussed, and the subject has been controversial. Many of the costs are intangible: temporary drop in proficiency and productivity while learning a new measurement system; plus some errors and duplication while operating with two systems. The more tangible cost effects usually are of very small magnitude, and dispersed widely throughout a firm's facilities and operations.

An over-riding consideration is that metrication must be accomplished in the normal course of business. There simply is no "separate pot of money" for metrication.

From a management viewpoint, metric conversion is a major, long-term project whose impact will be greatest in engineering and manufacturing areas; but which, to some degree, will affect every department in the company. Facing a change of this magnitude, scope, and duration, a businessman knows it must be managed effectively—and that the management objective should be to follow the "least-cost path," while getting maximum value from the change.

Philosophy and Rationale

In essence, the metrication cost management philosophy developed from experience of many organizations is: follow the rule of reason, and balance strong long-term planning with equally strong, realistic current cost control. In practical terms, this means: plan for metrication, but do not establish a separate budgetary line item for it.

The change to metric is by no means painless or free of cost. Badly handled, the costs—in terms of confusion and wasted effort, mistakes and botched plans, part variety proliferation, "bi-unital" operations, dual inventories, etc.—could be quite substantial. These factors are quite apart from the cost of changing or replacing measuring equipment and production machines.

Yet, experience has shown that precise, realistic cost estimates (before, during, or after) are impossible to determine—and, further, that a strong, thorough and sustained effort to forecast and measure costs is counterproductive.

Metrication cost appears to be a function of management attitude. If you direct an organization to convert over a period of years, using common sense, and give them no extra funds for metrication, the costs are unmeasurable. However, if you ask, "How much extra money and manpower will you need to go metric?"—you'll very likely receive estimates amounting to sizable sums.

Cost Categories

The assessment and allocation of costs probably is one of the least understood aspects of metrication. A thoughtful, item-by-item consideration of the following list of metrication cost elements reveals why this is true:

- Employee training
- Employee personal tools
- External standards activity
- Internal standards activity
- Measuring instruments
- Inspection equipment
- Machinery modification
- Metric or dual capability machine tools
- Metric supplies and materials

Metrication
cost
is a
function of
management
attitude

- Early obsolescence of machine tools and products
- Revision of computer software and computer reports
- Decreased productivity while working in two systems
- Errors
- Part variety proliferation
- Warehousing, inventories, and distribution
- Technical references and publications revision
- Man-hours spent on various metrication functions

By examining the foregoing items, it is evident that metrication cost is not amenable to management and control by methods that quantify and ascribe "numbers" to all cost elements and treat them as separate line items for accounting purposes.

Although the above list is not all-inclusive, it does convey a sense of the pervasiveness of metrication. It also helps one understand the comprehensiveness, precision, and intricacy of an accounting system that would isolate, track, and record tangible and intangible cost factors as widespread as these. Figure 14 shows a generalized breakdown of metrication costs from a manufacturing industry survey.

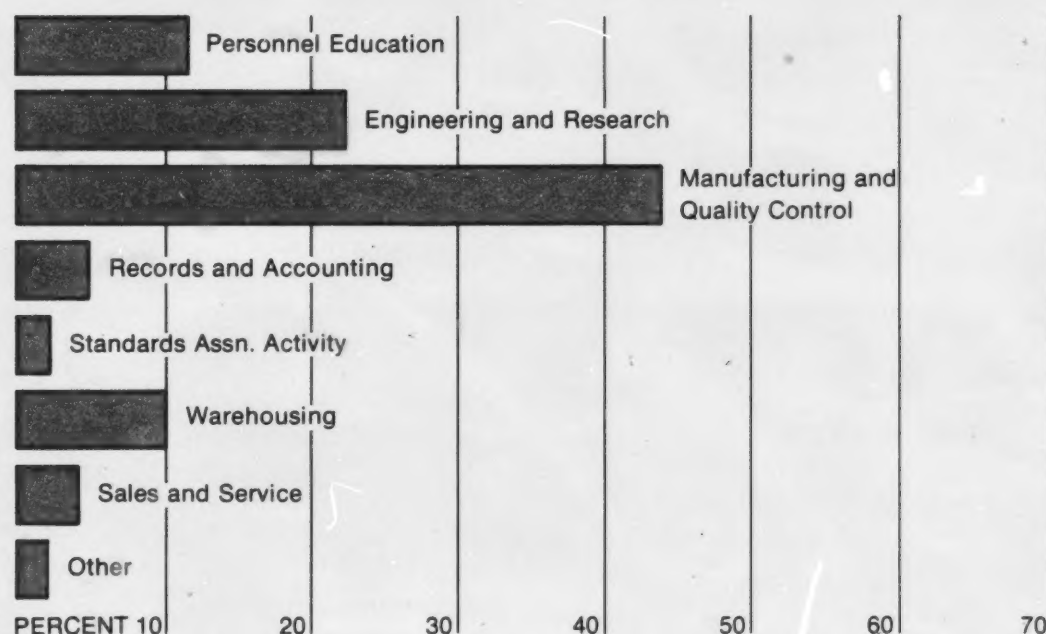


FIG. 14 Manufacturing Industry Survey: Allocation of Estimated Costs of Going Metric.

When analyzing functional tasks, costs of metric conversion can be considered as:

1. One-time capital costs
 - Purchase metric measuring instruments
 - Replace or modify machinery, equipment and tools
 - Dual inch and metric stock holdings

2. One-time operating costs
 - Personnel training
 - Efficiency drop-off while learning new system
 - Replacement of trade literature
 - Replacement of textbooks, handbooks
 - Metrication of engineering drawings, specifications, test procedures
 - Accelerated obsolescence of equipment and products
 - Added part variety during transition period
 - Modification of computer programs

Implementing Metric Cost Management

The accepted management strategy is to embody metric management into the existing organizational structure. The objective is to undergo a realistic and practical least-cost change. The advantage of this approach is direct management control, which enables cost-effective programming. Implementation strategy is based on normal product flow as the critical path. Cost accounting operates under normal controls and procedures:

Once a metrication program is underway, the cost of maintaining a procedure for complete, detailed cost accounting is unwarranted. Further, it tends to be self-defeating. That's because a "metrication budget," if established, acts as a magnet in attracting costs that otherwise would be covered in regular operating budgets.

Some companies do partially record metrication costs and report them within their systems for overall product program cost monitoring. Sometimes, management desires to know some portion of metrication costs for: tax reasons, internal analysis, statistical reporting, or for possible use in product pricing.

Instead of installing a system for tracking complete metrication cost, many firms believe they control the costs mainly by applying normal good management to their metric programs and by having no separate funding for metrication. Metrication is treated as an integral portion of program cost for a particular product. Each operating unit is expected to carry out its responsibilities within budget and through local ordering of priorities.

Proper timing and an orderly changeover are crucial factors in determining cost. Care should be taken to link metrication to normal cycles of change in products, facilities, and operations. The proper timing policy will set the pace of metrication at a level that assures progress at reasonable cost. The key to cost control in a firm engaged in metric conversion is a master plan that is dovetailed into its industry sector program and transition timetable. The idea is to "move with the metric tide."

No two situations are exactly alike. Each company and organization will have its own distinctive "cost profile" for metrication. The metric changeover will rise to a peak, then reach the tipover point, after which, instead of managing the phase-in of metric, we are managing the phase-out of inch items.

Metrication costs may be estimated against a variety of parameters. These range from dollars per employee, to percent increase in cost of components and materials purchased . . . from percent of value added to percent of annual sales. And, to further confound any serious attempt to obtain definitive cost data, the most universal "message" from hindsight is that "metrication cost is less than expected."

Perhaps the main value from an intensive effort to learn about the cost aspect of metrication is the thorough knowledge and understanding gained of the entire metrication process—along with insights leading to a realization that, although exact measurement and tight control of cost should not be attempted, the precepts of sound management are applicable. Thus, a special kind of "good management" may confidently be expected to bring about a reasonable success in minimizing metrication's cost, without ever knowing the exact dollar amount.

Metrication Management Checklist

I. STRATEGY AND PLANNING

- ☐ 1. **Determine Rationale for Going Metric**
 - ☐ a. Customers are adopting SI metric
 - ☐ b. Competitors are converting
 - ☐ c. To gain a competitive advantage
 - ☐ d. The inevitability of conversion
 - ☐ e. Overseas customer requirements
 - ☐ f. International company operations
 - ☐ g. Government laws, regulations, or programs
- ☐ 2. **Determine Company Metric Capability**
 - ☐ a. Availability of supplies in metric
 - ☐ b. Metric engineering and manufacturing capability
 - ☐ c. Availability of national and international metric standards
 - ☐ d. Ability of employees to learn and use metric
 - ☐ e. Top management's commitment to conversion program
- ☐ 3. **Determine How Conversion Can Improve Company Operations**
 - ☐ a. Eliminate unnecessary standards and sizes
 - ☐ b. Participate in national and international metric standards development
 - ☐ c. Eliminate dual stores and production
 - ☐ d. Improve designs and use latest technology in metric product development
- ☐ 4. **Develop In-Depth Plan**
 - ☐ a. Issue company policy statement
 - ☐ b. Assign responsibility for metrication
 - ☐ c. Plan should include timing and minimum cost considerations

II. ORGANIZATION

- ☐ 1. **Overall Organizational Plan**
 - ☐ a. Use normal line management channels
 - ☐ b. Handle metrication as a normal business function
 - ☐ c. Do not create separate organization for metrication
 - ☐ d. Each organizational unit retains cost accountability for its metrication efforts
- ☐ 2. **Management Must Appoint a Corporate Metric Coordinator Who Should:**
 - ☐ a. Be a senior company official
 - ☐ b. Have a broad perspective of company operations
 - ☐ c. Command respect and authority necessary to implement the program
 - ☐ d. Be able to work at all levels of the company
 - ☐ e. Be committed to metrication
- ☐ 3. **Corporate Metric Coordinator will Chair Corporate Metrication Committee**
 - ☐ a. Include representatives from all functional areas
 - ☐ b. Liaison with foreign divisions is important because of their metric experience
 - ☐ c. Establish lines of communication at all levels of the company
 - ☐ d. Develop company plan, obtain approval, and implement
 - ☐ e. Coordinate conversion at the division level
- ☐ 4. **Elements of the Coordination Function**
 - ☐ a. Determine inventory
 - ☐ b. Estimate lead time on tooling and gages
 - ☐ c. Determine availability of purchased components, materials, and supplies
 - ☐ d. Coordinate training with on-the-job application
 - ☐ e. If applicable, determine original equipment manufacturer transition plans
 - ☐ f. Determine most advantageous date for marketing the first metric product
 - ☐ g. Form subcommittees to investigate special problems or opportunities such as variety reduction, standards needs, legislation and regulations affecting conversion, and improvements in product design.

III. ENGINEERING

- ☐ **1. Engineering Considerations**
 - ☐ a. Determine availability of suitable metric standards
 - ☐ b. Develop company metric practice guide
 - ☐ c. Establish policy for dual dimensioning on drawings and specifications
 - ☐ d. Establish rounding policy
 - ☐ e. Establish marking system to distinguish nonmetric from metric items
 - ☐ f. Determine engineering training needs
 - ☐ g. Prepare for heavier design load during the transition
 - ☐ **2. Product Design Considerations**
 - ☐ a. Determine design objectives
 - ☐ b. Develop guidelines for metric product
 - ☐ c. Determine expected lifetime of metric product
 - ☐ d. Make best use of metrication as an opportunity to improve overall product design
 - ☐ e. Remember that modularization will ease the transition to an all-metric product
 - ☐ f. Determine if identifying metric parts of the product will be a marketing advantage
 - ☐ g. Coordinate designs with new production equipment and methods
 - ☐ **3. Metric Design Alternatives**
 - ☐ a. Pure inch/soft converted
 - ☐ b. Hybrid inch/metric
 - ☐ c. Pure metric/hard converted
-

IV. MANUFACTURING

- ☐ **1. The Decision to Convert or Replace Inch Machines and Tools Should be Based on:**
 - ☐ a. Conversion cost
 - ☐ b. Machine life expectancy
 - ☐ c. Delivery time for new machines
 - ☐ d. Delivery time for conversion equipment
 - ☐ e. Time required to convert existing equipment
 - ☐ f. Life expectancy of equipment following conversion
 - ☐ g. Ability of employees to use new or converted equipment
 - ☐ **2. Dual Operations can Cause Problems**
 - ☐ a. Establish marking code to distinguish inch from metric items
 - ☐ b. Determine additional storage and labor requirements caused by dual inventory and production
 - ☐ c. Determine spare and replacement parts needed for inch production equipment
 - ☐ d. Stock only those inch items necessary to complete existing contracts or authorized production runs
 - ☐ e. Coordinate conversion with suppliers
 - ☐ f. Establish plan and schedule for phase-in of SI metric units throughout all aspects of company internal communications; memos, reports, etc.
 - ☐ **3. Metrication and Labor**
 - ☐ a. Determine what effect conversions will have on existing labor agreements
 - ☐ b. Establish policy for replacing personal tools, supplying only tools necessary to do job
 - ☐ c. Develop a metric awareness program to foster union support for conversion
 - ☐ d. Determine training needs
 - ☐ e. Provide training needed in various job categories
-

V. MARKETING

- ☐ **1. Develop a Metric Marketing Plan**
 - ☐ a. Conduct comprehensive market research
 - ☐ b. If applicable, determine results of the metric programs of competitors
 - ☐ c. Determine effect of the metric aspect of your product on its end use
 - ☐ d. Re-examine foreign sales policy
 - ☐ e. If it is advantageous, identify metric aspects of the product
 - ☐ f. Determine effect of metrication on price of product
 - ☐ g. Coordinate marketing with other functions including engineering, manufacturing, and procurement
- ☐ **2. Explain Metrication to the People Who Sell and Service Your Products**
 - ☐ a. If applicable, inform them that conversion provided the opportunity to improve product.
 - ☐ b. Develop new sales literature, service manuals, and operating instructions
 - ☐ c. Explain metric sizes in dealers' service manual
 - ☐ d. If required by unique product design features, provide special tools to customers and service personnel to facilitate service
 - ☐ e. Plan spare parts backup so dealers do not have to hold excessive inventories
 - ☐ f. Determine training needs of salesmen, dealers, and service personnel
 - ☐ g. Equip order processing system to handle both systems of units

VI. COMPUTER OPERATIONS

- ☐ **1. Education and Analysis Needs**
 - ☐ a. Conduct metric practice training for systems people to help them identify potential problem areas in the conversion of computer operations
 - ☐ b. Survey day-to-day computer operations that will be affected
 - ☐ c. Modify or redesign programs as necessary
 - ☐ **2. Metric Units, Prefixes, and Symbols will cause Hardware Problems in Systems with Limited Character Sets**
 - ☐ a. Refer to ANSI Std. X3.50-1976 Representations for U.S. Customary, SI, and Other Units to be Used in Systems with Limited Character Sets.
 - ☐ b. Obtain alternative character sets
 - ☐ c. Develop alternative metric symbols
 - ☐ **3. Software Problems**
 - ☐ a. Prepare for additional storage requirements as a result of using two measurement systems
 - ☐ b. Correct metric practice in old programs if inconsistent with metric practices adopted by metric committee
 - ☐ c. Develop identifying code so post processor can print in desired measurement system
 - ☐ d. Adopt unit of measures code to identify customary and metric data in programs
 - ☐ e. Rewrite metric data tables in programs
-

VII. TRAINING

☐ **1. Planning the Program**

- ☐ a. Get top management commitment and financial support for training program
- ☐ b. Establish training objectives
- ☐ c. Define the learner population
- ☐ d. Conduct a task analysis to determine which employees need what amount of training
- ☐ e. Once a conversion schedule is approved, conduct metric awareness program to reduce employee resistance to conversion
- ☐ f. Use consultants and outside programs and materials only if they can fulfill your training needs

☐ **2. Conducting the Program**

- ☐ a. Teach only what employees need to know to do their job
 - ☐ b. Use modules to avoid overtraining and undertraining
 - ☐ c. Select proper training methods
 - ☐ d. Teach employees to "think metric"
 - ☐ e. Conduct training just prior to on-the-job need
 - ☐ f. Validate the training program
 - ☐ g. Keep track of training costs
-

VIII. COSTS

☐ **1. Metric Cost Sources**

- ☐ a. Designing the metric product
- ☐ b. Modification or replacement of machinery and equipment
- ☐ c. Dual inventory and additional storage costs
- ☐ d. Employee training
- ☐ e. Miscellaneous (marketing, legal, taxes, etc.)

☐ **2. Minimum Cost Strategy**

- ☐ a. Convert only when it makes economic sense
 - ☐ b. Develop an understanding of metrication at all levels of management
 - ☐ c. Develop some idea of costs but do not waste time preparing detailed cost estimates
 - ☐ d. Use sampling technique to estimate unit cost for a cross section of items
 - ☐ e. Extrapolate to find total metric cost estimate
 - ☐ f. Do not establish a special metrication budget
 - ☐ g. Follow normal accounting procedures using profit or cost centers as control points
 - ☐ h. Phase-in metric with new product designs
 - ☐ i. Replace machinery as part of the normal replacement cycle
 - ☐ j. Require local managers to achieve their metrication responsibilities within budget
-

Voice of Experience

An interesting thing happened when we wrote to knowledgeable people and asked them to provide material for a "voice of experience" section in this book. Our query was unstructured: each person simply was asked to tell us what one suggestion or bit of advice they might have for someone who faces the prospect of metrication.

Not surprisingly, the majority singled-out top-management support as the No. 1 factor. Hence, in the following sampling of replies, you'll find a recurring theme . . . as various individuals use their own words to express a similar cardinal point.

George D. Meixel
Ingersoll-Rand Co.

Metric Conversion is a Management Commitment. Many companies, faced with the prospect of impending conversion, have designated a manager or coordinator for conversion. They have then said to themselves, "Metrics is a technical subject and now that we've got a good technician on the job, we're metricated." This is a deception, and a company will rue the day it accepted such a course. Conversion to metrics requires the commitment of management. Top managers should familiarize themselves with the problems and opportunities offered by conversion, establish the plan and timetable that are best for the firm and its divisions, and then hold the lower echelons of the firm to the plan and its schedule.

C. Stanley Hines
Union Carbide Corp.

Top-Management decisiveness in adopting and implementing an overall metric policy is the key to developing momentum and cohesiveness in a corporate metrication effort. In a complex multinational company, a long range planning effort affecting all business areas requires high level awareness and sanction before effective coordination and program planning can be initiated. This may be equally true in smaller companies as well. Therefore, the single most important factor toward planning and managing the metric changeover is to develop top-management awareness of a need to start now on the long and, perhaps, involved investigations and planning activities that should precede the changeover to metric.

Louis R. Strang
Caterpillar Tractor Co.

In planning a metrication program, first get top-management commitment and company policy established. Don't overplan—get started. Start in engineering in a new long-range design to prove out your plan. Modify as required before being faced with a production timetable. Data Processing systems are likely to cause problems because most systems were not designed to accept both SI and U.S. non-metric units. Be willing to learn from initial experiences and change as required.

Melvin R. Green
The American Society of Mechanical Engineers

The plans for managing the metric changeover should be realistic and provide for re-examination of policies and definitions on a regular basis. The policies should provide enough flexibility for inclusion of SI units into standards in accordance with industry and public needs.

Dual units should be included in the text when they have utility; otherwise, the plans should emphasize the ultimate development of standards using SI units of measurement and quantities. Soft conversion of some standards is not desirable.

Eugene M. Ostap
Sears, Roebuck and Co.

Basically, there are three points that are somewhat common sense, but important nevertheless;

- 1) Commitment and support from top management is essential. A low-level ad hoc group out of the mainstream will not obtain the resources or base from which to be effective.
- 2) Do not expect the feedback inherent in other projects or systems. Considerable work will go into program planning and implementation, but it will be difficult to judge the effectiveness of truly "reaching" those who are the objects of the awareness and education programs. It is not a task that can be dispatched quickly.
- 3) Do not overwhelm your people with too much too soon, and time the programs to meet your needs. For the non-manufacturer who deals directly with the public, there is an added responsibility to make sure the consumer is involved from the start, and is comfortable with changes when they occur.

Louis F. Sokol
U.S. Metric Association, Inc.

In order to be successful, a metrication program in an organization must have the approval and support of management. Enthusiasm is necessary as is the importance of selecting a good metric coordinator. The SI should be strictly followed as defined by NBS SP 330 and practiced by ISO-1000 with no "American variations."

John J. Motley III
National Federation of Independent Business

The major problem for small firms faced with conversion is their inability to fund formal planning or hire the professional expertise needed to identify potential problem areas. In light of this, it is essential for the owners of these businesses to set aside enough time to thoroughly consider just how conversion will affect every aspect of their operation. Effective action is impossible until this task is completed.

Douglas R. Burke
Bell Laboratories

Before becoming enmeshed in conversion planning, clearly establish the objectives of your conversion. You may find the stated rationale has not been well thought out. Fuzzy motives, such as "keeping ahead of the competition" or reacting because "conversion is inevitable" will frustrate your planning. Insistence on clear objectives consistent with specific expected benefits will not only facilitate development of a conversion plan, but smooth its acceptance.

Russell Hastings
Clark Equipment Co.

Resist that noble impulse to write a metric practice guide for your own company. Instead, make a table for the quantities commonly used in your business, together with (1) "typical applications," (2) your present customary units, and (3) a minimum variety of metric unit-multiples—that are compatible with American National Standard Metric Practice Z 210.1-1976 and the ANMC Metric Editorial Guide.

By participating in an ANMC Sector Committee, you can then compare your own table with those of other companies and sectors to arrive at standardization across broad fields of use.

Carl A. Beck
Charles Beck Machine Corp.

I offer the following suggestions to the "small business sector":

1. Be aware. Keep up-to-date on what is developing. (e.g., subscribe to and read the ANMC "Metric Reporter").
2. Look for opportunities to save or obtain benefit, not just minimize cost.
3. Plan. Take all the time necessary for planning, even if it delays conversion, then convert a specific item (operations) as quickly as possible.

Harold L. Brock
Deere & Co.

Conversion to metric measurement is best accomplished by establishing a small pilot project that involves all organizational activities. Committee representatives of each activity can assess the impact and plan an orderly conversion that need not be disruptive or costly.

Development and adoption of new preferred sizes of product such as fasteners, materials, etc. requires a much longer conversion period because of economic and logistic considerations.

Thomas A. Hannigan
International Brotherhood of Electrical Workers

It is extremely important to understand the Metric Conversion Act of 1975 is not a national commitment to a new system of measurement, but a practical response to the increasing use of the metric system in the U.S. This law does not require that any group adopt the metric system; each industry is free to shift if and when it chooses, with the government ready to assist voluntary efforts. The initiative must come from private industry.

Metritication is everybody's business. A plan or response is necessary even if a decision not to convert was made. Organized labor must be involved in the planning process. Every International Union should appoint a Metric Coordination Committee and each local union should form a Metritication Committee.

Finally, available evidence supports the realistic assumption that the U.S. and the world will have a dual system of measurement for at least the next 50-100 years, and in some industries, forever. The inevitable existence of two measurement systems should be the key factor in all future public and private decisions. With proper planning and coordination, plus imagination and ingenuity, two system operation could maximize benefits and minimize costs.

Roy P. Trowbridge
General Motors Corp.

Metritication should not be commenced before a policy decision to go metric has been made at the highest company level. Once the decision has been made, establish a central metric focal point for the purpose of systematically organizing the various divisions and departments of the company. Do not try to plan the entire metric changeover at one time. Establish modest targets and try to meet them. Once the process has been started, do not turn back. Company personnel should become involved in national metric planning in order to properly set targets within their own companies. In addition, company personnel should take part in writing the metric standards which affect company products. The standards will be developed only as demand dictates and a company's metric decisions help create the demand. Above all, do not become an evangelist who endeavors to go metric at any cost; metric changeover should be based on least cost or no cost or savings decisions.

Office of the Secretary
THE METRIC SYSTEM OF
MEASUREMENT

Interpretation and Modification of the
International System of Units for the
United States

Section 3 of Pub. L. 94-168, the Metric Conversion Act of 1975, declares that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States. Section 403 of Pub. L. 92-360, the Education Amendments of 1974, states the policy of the United States to encourage educational agencies and institutions to prepare students to use the metric system of measurement as part of the regular education program. Under both these acts, the "metric system of measurement" is defined as the International System of Units as established by the General Conference of Weights and Measures in 1960 and interpreted or modified for the United States by the Secretary of Commerce (subsec. 4(4), Pub. L. 94-168; subsec. 403(a)(3), Pub. L. 92-360). The Secretary has delegated his authority under these subsections to the Assistant Secretary for Science and Technology. Accordingly, in implementation of this authority, the following tables and associated materials set forth the interpretation and modification of the International System of Units (hereinafter "SI") for the United States.

This notice supersedes the notice of the National Bureau of Standards published in the *Federal Register* of June 19, 1975 (40 FR 25637).

The SI is constructed from seven base units for independent quantities plus two supplementary units for plane angle and solid angle, listed in Table 1.

TABLE 1.—SI base and supplementary units

Quantity	Name	Symbol
SI base units:		
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd
SI supplementary units:		
plane angle	radian	rad
solid angle	steradian	sr

¹ "Weight" is the commonly used term for "mass."

² Wide use is made of "Celsius temperature" (symbol °C) defined by

$$t = T - T_0$$

where T is the thermodynamic temperature, expressed in kelvin, and $T_0 = 273.15$ K by definition. The unit "degree Celsius" is then equal to the unit "kelvin," but the degree Celsius (symbol °C) is a special name used instead of kelvin for expressing Celsius temperature. A temperature interval or a Celsius temperature difference may be expressed in degree Celsius as well as in kelvin.

Units for all other quantities are derived from these nine units. In Table 2 are listed 17 SI derived units with special names which were derived from the base and supplementary units in a coherent manner, which means, in brief, that they are expressed as products and ratios of the nine base and supplementary units without numerical factors.

TABLE 2.—SI derived units with special names

Quantity	SI unit		
	Name	Symbol	Expression in terms of other units
frequency	hertz	Hz	s ⁻¹
force	newton	N	kg m/s ²
pressure, stress	pascal	Pa	N/m ²
energy, work, quantity of heat	joule	J	N m
power, radiant flux	watt	W	J/s
quantity of electricity, electric charge	coulomb	C	A s
electric potential, potential difference, electromotive force	volt	V	W/A
capacitance	farad	F	C/V
electric resistance	ohm	Ω	V/A
conductance	siemens	S	A/V
magnetic flux	weber	Wb	V s
magnetic flux density	tesla	T	Wb/m ²
inductance	henry	H	Wb/A
luminous flux	lumen	lm	cd sr
luminance	nit	lm/m ²	
activity (of ionizing radiation source)	becquerel	Bq	s ⁻¹
absorbed dose	gray	Gy	J/kg

All other SI derived units, such as those in tables 3 and 4, are similarly derived in a coherent manner from the 26 base, supplementary, and special-name SI units.

TABLE 3.—Examples of SI derived units expressed in terms of base units

Quantity	SI unit	Unit symbol
area	square meter	m ²
volume	cubic meter	m ³
speed, velocity	meter per second	m/s
acceleration	meter per second squared	m/s ²
wave number	1 per meter	m ⁻¹
density, mass density	kilogram per cubic meter	kg/m ³
current density	ampere per square meter	A/m ²
magnetic field strength	ampere per meter	A/m
concentration (of amount of substance)	mole per cubic meter	mol/m ³
specific volume	cubic meter per kilogram	m ³ /kg
luminance	candela per square meter	cd/m ²

TABLE 4.—Examples of SI derived units expressed by means of special names

Quantity	Name	Unit symbol
dynamic viscosity	pascal second	Pa s
moment of force	newton meter	N m
surface tension	newton per meter	N/m
power density, heat flux density, irradiance	watt per square meter	W/m ²
heat capacity, entropy	joule per kelvin	J/K
specific heat capacity, specific entropy	joule per kilogram kelvin	J/(kg K)
specific energy	joule per kilogram	J/kg
thermal conductivity	watt per meter kelvin	W/(m K)
energy density	joule per cubic meter	J/m ³
electric field strength	volt per meter	V/m
electric charge density	coulomb per cubic meter	C/m ³
electric flux density	coulomb per square meter	C/m ²
permittivity	coulomb per meter	F/m
permeability	henry per meter	H/m
molar entropy	joule per mole kelvin	J/(mol K)
molar enthalpy, molar heat capacity	joule per mole kelvin	J/(mol K)

For use with the SI units there is a set of 16 prefixes (see table 5) to form multiples and submultiples of these units. It is important to note that the kilogram is the only SI unit with a prefix. Because double prefixes are not to be used, the

prefixes of table 5, in the case of mass, are to be used with gram (symbol g) and not with kilogram (symbol kg).

TABLE 5.—SI prefixes

Factor	Prefix	Symbol
10 ¹	deca	d
10 ²	hecto	h
10 ³	kilo	k
10 ⁶	mega	M
10 ⁹	giga	G
10 ¹²	tera	T
10 ¹⁵	peta	P
10 ¹⁸	exa	E
10 ⁻¹	deci	d
10 ⁻²	centi	c
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n
10 ⁻¹²	pico	p
10 ⁻¹⁵	femto	f
10 ⁻¹⁸	atto	a

Certain units which are not part of the SI are used so widely that it is impractical to abandon them. The units that are accepted for continued use in the United States with the International System are listed in table 6.

TABLE 6.—Units in use with the international system

Name	Symbol	Value in SI unit
minute (time)	min	1 min = 60 s
hour	h	1 h = 60 min = 3 600 s
day	d	1 d = 24 h = 86 400 s
degree (angle)	°	1° = (π/180) rad
minute (angle)	'	1' = (1/60)° = (π/10 800) rad
second (angle)	"	1" = (1/3 600)° = (π/1 080 000) rad
liter	L ¹	1 L = 1 dm ³ = 10 ⁻³ m ³
metric ton	t	1 t = 10 ³ kg
hectare (land area)	ha	1 ha = 10 ⁴ m ²

¹ The international symbol for liter is the lowercase "l", which can easily be confused with the numeral "1". Accordingly, the symbol "L" is recommended for United States use.

In those cases where their usage is already well established, the use, for a limited time, of the units in table 7 is accepted, subject to future review.

TABLE 7.—Units to be used for a limited time

nautical mile	angstrom	gal ¹
knot	bar	curie
standard atmosphere		roentgen
		rad ¹

¹ Unit of acceleration.

² Unit of absorbed dose.

Metric units, symbols, and terms that are not in accordance with the foregoing Interpretation and Modification are no longer accepted for continued use in the United States with the International System of Units. Accordingly, the following units and terms listed in the table of metric units in section 3 of the act of July 28, 1966, that legalized the metric system of weights and measures in the United States, are no longer accepted for use in the United States:

myriameter
stere
millier or tonneau
quintal
myriagram
kilo (for kilogram)

For more information regarding the International System of Units, contact the Office of Technical Publications, National Bureau of Standards, U.S. Department of Commerce, Washington, D.C. 20234.

BETSY ANCHER-JOHNSON, Ph. D.,
Assistant Secretary for
Science and Technology.

(PR Dec 76-94414 Filed 12-9-76; 9:45 am)

Federal Register Notice,
December 10, 1976



Public Law 94-168
94th Congress, H. R. 8674
December 23, 1975

An Act

To declare a national policy of coordinating the increasing use of the metric system in the United States, and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Metric Conversion Act of 1975".

SEC. 2. The Congress finds as follows:

(1) The United States was an original signatory party to the 1875 Treaty of the Meter (20 Stat. 709), which established the General Conference of Weights and Measures, the International Committee of Weights and Measures and the International Bureau of Weights and Measures.

(2) Although the use of metric measurement standards in the United States has been authorized by law since 1866 (Act of July 28, 1866; 14 Stat. 339), this Nation today is the only industrially developed nation which has not established a national policy of committing itself and taking steps to facilitate con-

Metric Conversion Act of 1975,
15 USC 205a note,
15 USC 205a.

SEC. 3. It is therefore declared that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.

(1) "Board" means the United States Metric Board, established under section 5 of this Act; 15 USC 205c.

(2) "engineering standard" means a standard which prescribes (A) a concise set of conditions and requirements that must be satisfied by a material, product, process, procedure, convention, or test method; and (B) the physical, functional, performance and/or conformance characteristics thereof;

(3) "international standard or recommendation" means an engineering standard or recommendation which is (A) formulated and promulgated by an international organization and (B) recommended for adoption by individual nations as a national standard; and

(4) "metric system of measurement" means the International System of Units as established by the General Conference of Weights and Measures in 1960 and as interpreted or modified for the United States by the Secretary of Commerce.

independent instrumentality to be known as a United States Metric Board. Metric Board, Establishment, 15 USC 205d.

(b) The Board shall consist of 17 individuals, as follows:

SEC. 6. It shall be the function of the Board to devise and carry out a broad program of planning, coordination, and public education, consistent with other national policy and interests, with the aim of implementing the policy set forth in this Act.

Sources of Additional Information

American Iron and Steel Institute
 1000 16th Street, NW, Washington, D.C. 20036
 (202) 452-7100

Metric Practice Guide: Units and Conversion Factors for the Steel Industry (contact AISI for ordering information)

American National Metric Council
 1625 Massachusetts Avenue, NW, Washington, D.C. 20036
 (202) 232-4545

Metric Reporter, biweekly newsletter, \$35 annual subscription
 Managing Metrication in Business and Industry, Metric Editorial Guide, Guidelines for Writers of SI Metric Standards and Other Documents and publications (write for free catalogue)
 Information on metric activities in business, industry and government

American National Standards Institute
 1430 Broadway, New York, New York 10018
 (212) 354-3300

Bibliography of Metric Standards, free
 American National Standard Z210.1-1976, (Metric Practice), \$1.75

American Petroleum Institute
 2101 L Street, NW, Washington, D.C. 20037
 (202) 457-7000

Metric Practice Guide (Publication 2563), \$4
 Conversion of Operational and Process Measurements to the Metric (SI) System (Publication 2564), \$4
 Use of Metric Units on Petroleum Packages During Conversion (Publication 2564, Annex A), \$1.50
 Transition to Metric, free brochure
 3/4 inch videotape cassette or 16mm sound film (designed to promote company awareness of the petroleum industry's conversion), \$60 per copy

American Society for Testing and Materials
 1916 Race Street, Philadelphia, PA 19103
 (215) 299-5400

ASTM Standard E 380-76, Metric Practice (identical to ANSI Z210.1-1976), \$4 (less 20% to ASTM members, quantity rates available on request)

American Society of Mechanical Engineers
 345 East 47th Street, New York, New York 10017
 (212) 644-7722

SI-1 ASME Orientation and Guide for Use of SI (Metric) Units, \$2 (ASME Members \$1)
 SI-2 ASME Test Booklet—SI Units in Strength of Materials, \$3 (ASME members \$1.50)
 SI-3 ASME Test Booklet—SI Units in Dynamics, \$4 (ASME members \$2)
 SI-4 ASME Test Booklet—SI Units in Thermodynamics, \$6.50 (ASME members \$3.25)
 SI-5 ASME Test Booklet—SI Units in Fluid Mechanics, \$5 (ASME members \$2.50)
 SI-6 ASME Test Booklet—SI Units in Kinematics, \$3 (ASME members \$1.50)
 SI-7 ASME Test Booklet—SI Heat Transfer, \$5 (ASME members \$2.50)
 SI-8 ASME Text Booklet—SI Units in Vibration, \$3 (ASME members \$1.50)
 SI-10 Steam Charts, \$25 (ASME members \$12.50)

Industrial Fasteners Institute
1505 East Ohio Building, 1717 East 9th Street, Cleveland, Ohio 44114
(216) 241-1482

Metric Fastener Standards, \$35

Institute of Electrical and Electronics Engineers
345 East 47th Street, New York, New York 10017
(212) 644-7900

IEEE Standard 268-1976, Metric Practice (virtually identical to ANSI Z210.1-1976 and ASTM E 380-76), \$4, IEEE members \$3.20 (plus \$2 shipping and handling charge)

Motor Vehicle Manufacturer's Association
300 New Center Building, Detroit, Michigan 48202
(313) 872-4311

"Transition to Metric," 14-module metric training set, individual modules are available (contact MVMA for ordering information)

National Bureau of Standards
Metric Information Program, Washington, D.C. 20234
(will be replaced by the U.S. Metric Board when the Board is established)
(301) 921-2658

National speakers bureau

Free review of documents for metric usage

Information on correct metric usage and government agency activity

Metric publications (contact NBS for ordering information)

National Fluid Power Association
3333 North Mayfair Road, Milwaukee, Wisconsin 53222
(414) 259-0990

Metrication Progress Report (executive summary of metric standards in the fluid power industry), \$15, NFPA members \$10

ISO/TC 131 (Fluid Power Systems and Components), Annual Report, free. ISO & ANSI metric standards for the fluid power industry (contact NFPA for ordering information)

Society of Automotive Engineers
400 Commonwealth Drive, Warrendale, PA 15096
(412) 776-4841

J916-Rules for SAE Use of SI (Metric) Units, \$2.75

Society of Manufacturing Engineers, Metric Information Center
20501 Ford Rd., P.O. Box 930, Dearborn, Michigan 48128
(313) 271-1500

Free list of technical papers on metric conversion, videotapes, and training materials

Standards Engineers Society, Minnesota Section
c/o Howard Bullis, 2577 Crestline Drive
White Bear Lake, Minnesota 55110

Managing Metrication, 1973 edition with 1976 inserts, \$2

U.S. Metric Board (see National Bureau of Standards)

METRICATION POINTERS

Malcolm E. O'Hagan, President
American National Metric Council

1. Don't fall into the trap of taking a simplistic view of metrication.
2. Don't underestimate the implications of metrication but don't overestimate the problems of conversion.
3. Metrication must be a gradual evolutionary process. A transition period requiring dual capability and bilingualism is unavoidable.
4. Learning the metric system is an educational task. Metrication is a management task.
5. Don't wait and beg Uncle Sam to tell you how to conduct your metrication program. Be responsible and do what you know needs doing.
6. Take responsible action to preserve private sector initiative and show that voluntary programs can and do work.
7. A clearly stated metrication policy enunciated by the chief executive officer is a prerequisite to a successful conversion program.
8. A detailed impact analysis and a general plan for conversion are essential ingredients for a successful conversion program.
9. Identify cost factors associated with metrication. Also identify the negative cost factors of not converting.
10. Put metric thinking and consideration in a future context and not in a past or even present context.
11. Apply the project management concept to metrication.
12. Don't invent the metric wheel—someone has beaten you to it and they haven't patented it.
13. Don't metricate in a vacuum—be aware of the metric environment.
14. Don't sacrifice long-term benefit for short-term convenience and expediency.
15. Don't metricate for metrication's sake—make all conversion meaningful.
16. As in all human endeavors humans are the key to success. While metrication involves changes in things, these changes must be effected through people.
17. If your product is a measurement-sensitive consumer product let the marketing department set the conversion strategy.
18. Value for money and service to customers must determine conversion strategy.
19. Follow the principles enunciated in ANMC's "Metric Guide For Employee Training."

CONVERSION FACTORS U.S. Customary to SI Metric Units

	When you know:	You can find:	If you multiply by:
LENGTH	inches	millimeters	25.4
	feet	centimeters	30.48
	yards	meters	0.91
	miles	kilometers	1.61
AREA	square inches	square centimeters	6.45
	square feet	square meters	0.09
	square yards	square meters	0.84
	acres	hectares	0.41
MASS	ounces	grams	28.35
	pounds	kilograms	0.45
	short tons (2000 lb)	megagrams (metric tons)	0.91
LIQUID VOLUME	cubic inches	cubic centimeters	16.39
	ounces	milliliters	29.57
	pints	liters	0.47
	quarts	liters	0.95
TEMPER- ATURE	gallons	liters	3.79
	degrees Fahrenheit	degrees Celsius	5/9 (after subtracting 32)

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2-9 copies	\$3.50	\$4.00
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American National Metric Council
1625 Massachusetts Avenue, NW
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(202) 232-4545



The American National Metric Council is a nonprofit organization whose purpose is to provide guidance and coordination for voluntary conversion to the metric system in the United States.

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